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ENGINEERING

An Illustrated Weekly Journal

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OUT OF THE STRONG CAME FORTH WEAKNESS

WALKING round an exhibition is more fatiguing than almost anything else, except perhaps walking round a museum. An effective way of prolonging one's fatigue life is to select some purpose for the visit which is equally applicable to all exhibits. Thus at the Engineering Exhibition at Olympia, after completing the main business of one's visit, it is highly rewarding to wander round looking superficially at all exhibits and criticising them for their refinement of design —or lack of it. " Robustness " used to be a word of praise in design, but now it smacks of unnecessary material, if not of ignorance on the part of the designer.

The managing director of the Brush Group, Mr. Ian Morrow, is reported to have said at Olympia that if we are to compete successfully with our neighbours in the European Common Market we must stop making products that are too good for the job. In the end, it is the customer who pays for over-insurance in design. If you supply a hundred machines which are so robust that they all remain in service for twenty years without a failure of any kind, it is quite possible that you have not given the customer what he wants. It may well be that he would have preferred a not inconsiderable decrease in first cost at the expense of an occasional failure, which would have been a nuisance but would not have cost much to put right.

The cause of over-insurance in design undoubtedly goes back to the fact that most designers were trained in a heavy engineering works. Even to-day it is the large firms which do most of the training of future engineers, and large engineering firms are usually in heavy engineering. The result is washing machines designed on sound marine or railway engineering lines—very robust but quite impracticable for the housewife. That this tradition is disappearing is evident from a walk round Olympia; some of the heavy, not to say clumsy designs are in fact imported from the Continent. Some of the British designs are highly refined, using the minimum of material, though there are others which appear to have gone into production while the design is still in almost draft form.

This aspect of design is not of interest to designers only. It affects every department of the business—those in production (who have to produce the design), research (who can contribute to the refinement of design), marketing (who are frustrated if their competitors are selling lighter and better designs), and the board of directors (who naturally look to the long-term effects of product design). In the case of machines and equipment which have to withstand only light loads, or are virtually static, refinement of design presents no insuperable difficulty. In those cases where fluctuating stresses operate, however, and are likely to cause fatigue failure, the problem is not simple. Surprisingly little is known about the mechanism of fatigue and how to design for it, but sufficient is known for designers who have not troubled about it before to study the information that is already available and weave some of their conclusions into their future work.

Though the problem of fatigue has been known to engineers for many years, and has been prominent in relation to aircraft more recently, its significance is increasing because of the greater use of the newer alloys and because of the rise in the number of machines likely to be affected by it. The fatigue characteristics of some of these alloys are such that however light the load on a component, it will eventually cause failure if it is repeated often enough. This point has been brought out in an article, entitled " Limited Life Design," which was published in ENGINEERING for August 23 and 30. The article, in its original form, was presented to the 1956 British Association meeting, and in it Professor J. A. Pope and his co-authors review what can be done by designers now, and what needs to be done by research and the patient collection of data.

Briefly, there are three difficulties in designing for dynamic conditions: (1) the fact that the results of fatigue tests on polished specimens of a material show a wide scatter of results; (2) the presence of stress-raisers, such as machining marks, which are not present in the specimens but are highly significant in the finished product; (3) the difficulty of formulating the law of cumulative damage—which, if reliable, would enable designers to design in accordance with the anticipated working conditions of the product. The authors of the paper draw attention to the need for more experimental data, but they offer advice which is immediately applicable, namely, how to design so that, in the event of failure, sufficient warning is given for the machine to be taken out of service before any serious damage is done. Thus, for example, instead of putting all the load on one member, such as the spar of an aircraft wing, which might cause disastrous results if it failed by fatigue, it is better to replace the one component by several, designed in such a way that when one fails the others can take the strain until the machine comes out of service. This is known as " fail safe." It is by no means a new idea, but to apply it deliberately is a novel principle which will have increasing application.

Cover Picture. *S.T.S. "Vitrina," a tanker of 32,000 deadweight tons, was launched in April of this year. Her fitting out was completed in early August, when she made her maiden voyage. She has now been put on to the "crudes" run from Singapore to Rotterdam. With the heavy placing of orders for tankers during the past 18 months, the carrying capacity of the world's tanker fleet is likely to grow at a rate of around 11 per cent. a year until 1961.*

* * *

Plain Words

When he opened the Engineering Exhibition at Olympia, Sir Christopher Hinton appeared almost to play down the story of enterprise which brought Calder Hall atomic power station into being. "It would have been easy," he said, "with so many scientific discoveries at our disposal to let them run away with us and to be forced into attempting to reach objectives that were beyond our grasp. So, from the outset, we adopted the principle that it was our business not to be clever, but to be successful. We aimed at solving problems which were completely novel in terms of engineering practice, which was so conservative that it could not go wrong."

"Not to be clever but to be successful"—that's not a bad slogan for any engineering organisation. As an American, Mr. Peter Drucker, has said in his book on management, the first purpose of a business is to remain in business; making a profit is a means to that end, not an end in itself. Making a profit was not a consideration which Sir Christopher Hinton had to take into account, but being successful was the criterion which he substituted. The groups of engineering firms which have since come into the atomic energy business will benefit increasingly from the early vision and success of the Atomic Energy Authority and their advisers. They, in turn, are faced with extremely difficult decisions which require, in the last analysis, a willingness to venture.

But to be successful the pioneers of this form of power undoubtedly had to be clever. In Sir Christopher's own words, "The Calder Hall reactors used materials and techniques of construction which were well established, and although they were perhaps applied more daringly than had been done in the past, the standards which were applied to construction and inspection were such as gave every assurance that the well tried techniques that were used would give a reliable plant." Even so, no one concerned with the early work on atomic power could at that time be absolutely certain that success was inevitable. It would be an exaggeration to say that there was a good deal of luck, but there were certainly times when a few people got cold feet. How could it have been otherwise? They were bent on achieving something that was completely novel, and on achieving it before anyone else working in the same field. Their achievement is now a part of history. But the spirit which animated them still lives—is even now being directed to new projects. It is not reserved for an *élite*; it is available to everyone—even to those of us who get cold feet occasionally.

THE AIRCRAFT INDUSTRY:

In reviewing some aspects of the annual exhibition of the Society of British Aircraft Constructors, which concludes its run at Farnborough on Sunday, September 8, we deal first with the new engines on view because it is the British aero-engine manufacturers who form the main source of satisfaction in the industry to-day.

Two new power units shown by the de Havilland Engine Company, Limited, Leavesden, Hertfordshire, were designed largely with the mixed-power interceptor concept in mind—the Gyron Junior turbojet and the Spectre rocket engine—but also with many other possible applications. The mixed-power concept, it may be recalled, seeks to reap the benefit of the rocket's supreme performance at very high altitudes, and the improved manoeuvrability that it confers, where the air-breathing engine is beginning to suffer from air-starvation, while avoiding the limitations imposed by the voracious fuel consumption of the rocket, the latter being brought into operation only for "chasing" on the climb or at operational altitude.

SPECTRE

Dealing first with the Spectre rocket engine: this engine, on view in the Static exhibition, is also appearing in the flying display under the belly of a Canberra flying test-bed, and in the prototype Saunders-Roe supersonic interceptor. As the rocket unit of a piloted supersonic interceptor, it has been designed to provide continuously-variable thrust from idling to maximum, and to stop and start readily in flight at the pilot's commands. The Spectre has been engineered to rigorous aircraft standards of safety and reliability, and it forms a compact installation incorporating all the pumps, valves and controls in one unit. Performance figures have not been revealed, but it can be said that the Spectre was designed to the same specification as the Armstrong Siddeley Screamer rocket which developed a maximum thrust of 8,000 lb.

The Spectre is a liquid-fuel rocket employing hydrogen peroxide and kerosine or gasoline as propellants—hydrogen peroxide being selected as the oxidant because it is safe to handle and can be stored for periods of years without evaporation. It also has the advantage that, with the aid of a catalyst, it can be used as a monofuel, decomposing into steam and oxygen, for driving turbopumps and other auxiliaries. Kerosine, or gasoline, is the obvious choice for fuel in a mixed-power aeroplane which will be carrying such fuel anyway for the turbojet engine, and also because when used with hydrogen peroxide, easy smooth combustion is ensured with no danger if the propellants are inadvertantly mixed outside the combustion chamber.

The main cylindrical structure of the Spectre engine contains the turbine for driving the propellent pumps, the catalyst chamber and the combustion chamber. Ahead of this integral assembly is the gearbox on which are mounted the centrifugal-type propellent pumps. The various control valves and associated linkage systems are located on the port side. Under the gearbox is the oil sump, and on the starboard side are the starter unit and fuel-cooled oil cooler.

A small high-speed turbine energised by a separate supply of hydrogen peroxide is employed for driving the propellent pumps, and the associated decomposition products from this unit are subsequently directed through the main combustion chamber. The alternative to this low-loss system would have been for the turbine exhaust gases to be passed directly to atmosphere. This latter arrangement, although presenting less of a development problem, would have reduced the potential performance of the engine as a result of the diminished mass flow of the main propulsive jet.

Combustion at other than correct oxidant/fuel mixture ratios (about 9 to 1) results in lower, rather than higher, gas temperatures. With imperfect mixing, this implies the incurrence of "cold" spots on the combustion chamber wall as opposed to hot spots.

In the Spectre it is necessary to utilise the flow of hydrogen peroxide for chamber and nozzle cooling purposes. The feed pipe, from the oxidant pump at the front of the gearbox passing rearwards to the chamber and nozzle assembly, is apparent along the top of the engine.

Packs of silver-plated gauze are provided in the catalyst chamber and the oxidant is decomposed on being passed through these. It is a feature of all modern hydrogen-peroxide engines that the fuel and oxidant are not admitted to the combustion chamber as liquids; the fuel is injected into the hot gaseous products of decomposition where smooth thermal ignition, of an inherently safe nature, occurs. During starting and shut-down, a purge of steam cleanses the combustion chamber and obviates the possibility of a dangerous accumulation of liquids.

Several marks of Spectre have been designed and, in addition to the variable-thrust units developed for piloted interceptor aircraft, there are fixed-thrust versions suitable for assisted-take-off units and missile power plants.

GYRON JUNIOR

The Gyron Junior turbojet is being developed for supersonic high-altitude interceptor and tactical aircraft and, the manufacturers state, it will be fitted "in certain new British military aircraft of which no details may yet be given." It is known that Saunders-Roe Limited are showing great interest in the Gyron Junior-Spectre combination for a developed version of their mixed-power interceptor; and the fact that the engine displayed has an air-bleed manifold, through which a supply of air can be tapped from the compressor for boundary-layer control, suggests that deck-based aircraft are among the possible applications.

The Gyron Junior is being prepared in several versions; the engine on view at Farnborough, in the static show and installed in a Canberra flying testbed, is the first of the series and develops a static thrust of 7,000 lb. without afterburning. Its weight has not been revealed, but it is said to be "exceptionally light" and compact with a diameter of 35 in. and a length of 100 in.

The Gyron Junior is still heavily classified, but it is known to be a scaled-down version of the big Gyron which is now on the part-publication list, and basically resembles that engine. The Junior has, it is believed, fewer compression stages, and it is fitted with a Dowty fuel system whereas the big engine has a Joseph Lucas fuel system.

GYRON SENIOR

Originating as a private venture, the Gyron supersonic turbojet received a Government development contract soon after its first test-bed run in 1953. Now, in the light of the White Paper on defence policy, official support has been withdrawn and, again, Gyron development continues to be privately sponsored by the de Havilland Engine Company, Limited, because although the Government have at present lost interest in the supersonic piloted fighter, a large section of the aircraft industry is not yet convinced that the day of the piloted interceptor is past. In particular, the Hawker Aircraft Company, Limited, are proceeding with a private-venture successor to the Hunter, the P.1121, which will be powered by the Gyron.

The Gyron has an overall length of 155·5 in., including the exhaust cone assembly and propelling nozzle, and a diameter of 49·9 in. It has a dry weight of 4,200 lb., and a rated static thrust at sea level of 20,000 lb., with a corresponding specific fuel consumption of 1·04 lb. per lb.-thrust per hour. With afterburning,

PROPULSION GOES SUPERSONIC—

and a fully variable convergent/divergent propelling nozzle, thrusts well over 25,000 lb. have been achieved.

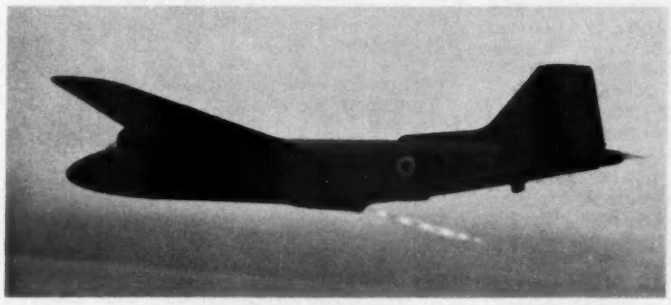
Designed for operation up to speeds of Mach 2 to 3, the Gyron has only a moderate pressure ratio (unofficial American sources have quoted a figure of about 6 to 1), using a single-spool seven-stage axial compressor of constant diameter, with a direct-entry annular air intake and variable-incidence inlet guide vanes, hydraulically actuated and automatically controlled by a suitable engine-operating parameter. An unusual feature in an engine of this size is that only two main bearings are employed, this being made possible by adopting a very rigid compressor and main-shaft assembly. The combustion chamber is annular and is claimed to be the first large British combustion system of this type to utilise an atomising fuel-injection system. The two-stage turbine is overhung from the rear roller bearing, a system of spokes within the first-stage nozzle blades, which are hollow, providing radial support for the rear bearing. They also provide passages for the turbine cooling air supply.

In the current engine the compressor blades are of stainless steel, but tests have been carried out on a titanium-bladed compressor with substantial weight saving. The compressor rotor and the shaft joining it to the turbine is in high-tensile alloy steel, and the turbine discs are heat-resisting ferritic steel forgings. Nimonic alloys are employed in the combustion chamber, the turbine blading and the first and second-stage nozzle blades, the hollow first-stage blades being of welded sheet and the second-stage machined from solid forgings. In the "cold" parts of the engine, the outer casings are in light alloys—the air intakes comprising a magnesium-zirconium alloy casting, and the forward part of the compressor casing comprising a pair of aluminium alloy castings. In the hot parts, the casings are of Fortiweld high-tensile welding steel.

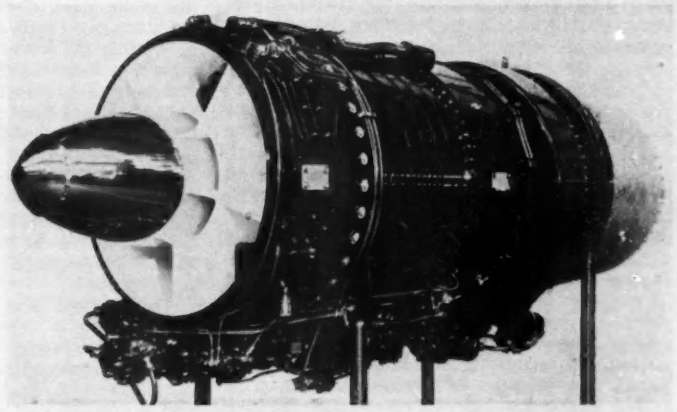
The Gyron still has plenty of "stretch" to exploit, and de Havilland are planning further extensive work on supersonic intake design and variable-area propelling nozzles.

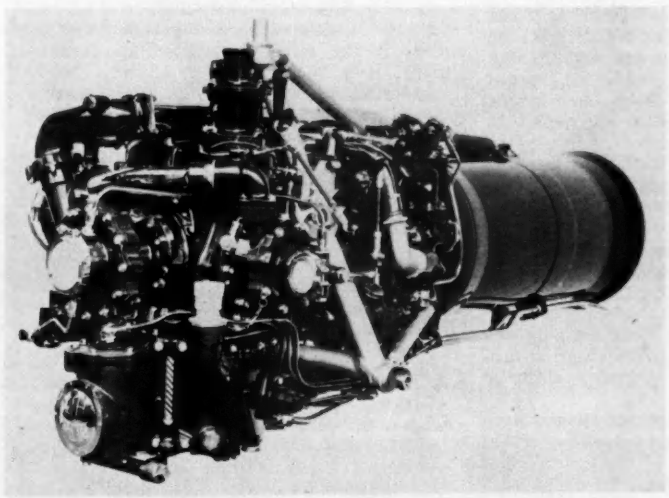
IROQUOIS

Another approach to the supersonic turbojet is shown in Canada's new engine, the Iroquois, which was unveiled recently in London by Sir Roy Dobson and which is being shown at Farnborough by its designers and constructors, Orenda Engines Limited, Malton, Ontario. The Iroquois was conceived specifically—and as a private venture—as the power unit for Avro Canada's Arrow supersonic interceptor which is expected to fly later this year and for which, when the specification was issued some seven

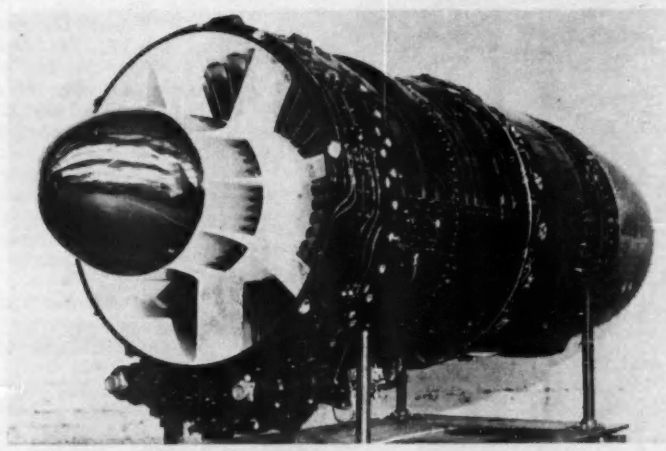


Diamond shock-wave patterns can be seen in the jet flame of the Spectre rocket engine.

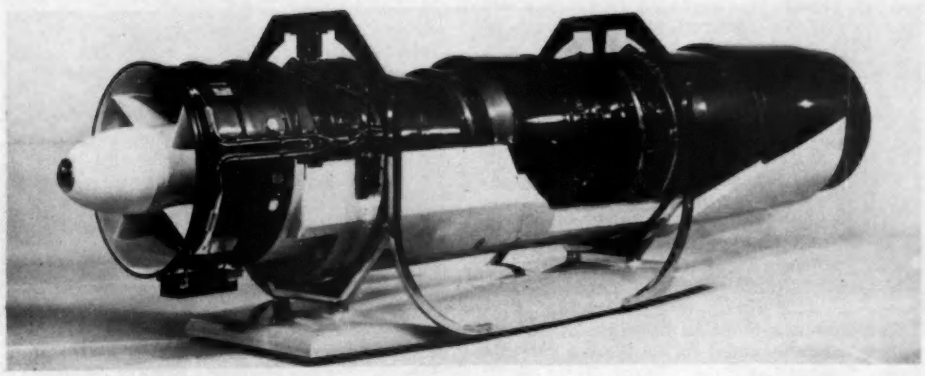




The Gyron Junior supersonic turbojet (above) is a scaled-down version of the 20,000 lb.-thrust Gyron (below).



The Spectre variable-thrust rocket engine is designed for piloted "mixed power" aircraft.



Canada's supersonic turbojet, the Iroquois, develops more than 20,000 lb. thrust without after-burning. The engine has been specially developed for the Avro Canada Arrow interceptor. The Iroquois is now undergoing flight trials on a Boeing B.47 testbed.

—BUT TRANSPORT IS STILL SUBSONIC

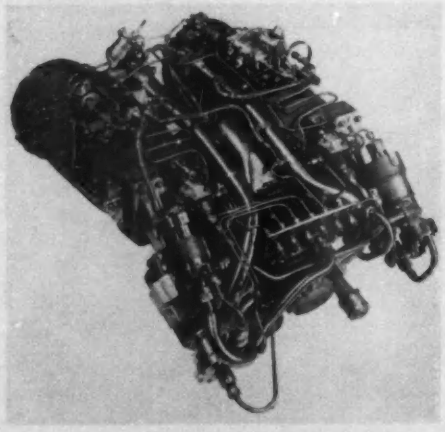
years ago, there was no other suitable engine in sight.

The Iroquois, which appears to be of the same order of dimension as the Gyron, is claimed to be exceptionally light in weight, with a thrust-to-weight ratio greater than 5 to 1 without afterburning. The engine has not yet been type tested; it has developed considerably more than 20,000 lb. thrust without afterburning.

Although the Iroquois is believed to utilise a pressure ratio appreciably higher than that of the Gyron—it is a two-spool engine—it is well below that of current large American turbojet developments which, Orenda suggest, are still thinking largely in terms of high subsonic cruising whereas Orenda believe that interceptor operations will, for the most part, be carried out well above Mach 1. This engine is expected to achieve its optimum economy around Mach 2. The two-spool configuration, the manufacturers claim, provides sufficient flexibility for adequate subsonic efficiency with greater simplicity than variable stator blading.

From the start the afterburner has been designed as an integral part of the main engine and, in the Arrow-Iroquois installation, engine and afterburner are closely coupled. By grouping all the accessories and inflammable fluid lines below the engine and enclosing them with a titanium firewall (the white structure in the illustration), it becomes possible to direct a controllable by-pass airflow, spilled from the air intake, over the afterburner. By this means, the manufacturers claim, much of the advantage of a fully convergent-divergent nozzle is obtained at speeds around Mach 2, at a considerable weight saving. Nevertheless, later developments of the engine may be fitted with such a nozzle.

The engine has been designed from the start for production and with simplicity and light weight as primary requisites, the number of parts being some 20 per cent. fewer than on the Orenda turbojet which develops only about one-third of the thrust of Iroquois. This is one of the ways in which weight has been saved; another is the use of a five-point suspension system in which all the loads in the casing-skin are taken out tangentially, so that no radial stiffening is required; but probably the most significant factor in weight-saving in the Iroquois is the extensive use of high-purity titanium, notably in the compressor; and Orenda claim to have achieved significant advances in machining and welding techniques for titanium.



The Double Scorpion rocket motor is a high-altitude unit for piloted fighter aircraft.

The Double Scorpion is installed in the bomb bay of the Scorpion Canberra which recently secured the altitude record.

DOUBLE SCORPION

Another rocket engine designed specifically for aircraft applications, Napier's Double Scorpion, has made news during the course of its programmed flight tests in a Canberra flying testbed by beating the world altititude record for aeroplanes, as recorded elsewhere in this issue. The designers and constructors of the Scorpion, D. Napier and Sons, Limited, Luton, are one of the member firms of the English Electric Aviation Group, and they are developing the Scorpion as a high-altitude power unit for jet fighters to boost performance at heights where air-breathing engines are approaching their limit. English Electric, it may be recalled, are the designers of the Canberra aircraft and also of the P.1 supersonic fighter.

The Double Scorpion is a bi-fuel thermal-ignition engine utilising, as does also the de Havilland Spectre, hydrogen peroxide and kerosine as propellents. The Double Scorpion is, however, a smaller unit than the Spectre, and it provides two stages of thrust, having two combustion chambers which can be brought into action separately or together. The precision with which the pilot can start and stop the unit in flight was amply demonstrated to the Press in a superbly polished display flight made by the Scorpion-Canberra flying testbed last week. In this aircraft the rocket engine is fitted in the bomb bay, the bomb-doors being cut away to clear the cowling which completes the underbelly line when the doors are closed. Forward of the rocket unit is a large cylindrical tank for the high-test peroxide. Kerosine is drawn from the standard aircraft fuel tanks. Installing and removing a Double Scorpion unit are simple operations since there are only the two propellent-pipeline connections and an electrical plug and socket for connecting the control and instrumentation circuits to the aircraft's electrical supply.

The propellents are fed separately to the combustion chambers by a single turbopump located between the two chambers at the forward end of the unit. The pump turbine is itself "cold"-driven by the catalytic decomposition of high-test peroxide in a small chamber on the forward starboard side. The main flow of high-test peroxide is directed into the combustion chamber through a catalyst pack whereupon it decomposes into steam and oxygen; not until the steam pressure has risen sufficiently to actuate a pressure switch is the kerosine injected.

The performance of the Double Scorpion is undisclosed, but it is understood that the thrust/weight ratio is particularly impressive.

NEW SHAFT TURBINES

Leaving the supersonic engine scene, two new 950-1,160 s.h.p. centrifugal gas-turbines now under development are shown in model form by Armstrong Siddeley Motors Limited, Coventry: the P.181, a free power-turbine engine for helicopter shaft drives, with a rearward-facing power take-off shaft; and the P.182, which differs from the P.181 in having a single-shaft turbine assembly and a forward-facing propeller shaft.

During the past few months there has been talk of an ambitious supersonic vertical take-off airliner—a project that would without doubt involve Britain in huge expenditures on development, against a future return that is as yet quite uncertain. The less optimistically-minded taxpayer visiting Farnborough may well experience some relief in observing that the present generation of new and projected transport aircraft are still largely traditional, although he may also feel disappointment in not seeing the Rolls-Royce Flying Bedstead and the Short and Harland vertical take-off research aeroplane, the S.C.1. Two of the latter have so far been built, but the Rolls-Royce RB.108 engines destined for the take-off rôle for the first aircraft have only recently been delivered to the company, so that in fact the S.C.1. has not yet had a chance to try out its capabilities in vertical flight —a situation that has arisen as a result of the cuts in research expenditure dictated by the Government's new defence policy. Any minute now, however, the S.C.1. expects to commence hovering trials on a test gantry to prove the jet-lift controls and the auto-stabiliser.

Turning to the transport aircraft taking part in the flying display: the Comet 3 air liner shown by the de Havilland Aircraft Company, Limited, Hatfield, is still "standing in" for the Comet 4, construction of which is, however, well advanced at Hatfield. It looks like flying before the end of the year, and should almost certainly appear in person at next year's display. Meanwhile, the Comet 3 now has installed the operational 10,500 lb. thrust Avons and many other features of the Comet 4—improved air conditioning, a developed de-icing system, "Q"-feel to provide harmonious elevator control over the speed range, and much of the latest instrumentation.

The HDM.105 transport aircraft shown by F. G. Miles Limited, Shoreham-by-Sea, appeared in the Paris show earlier this year and was described in the June 14 issue of ENGINEERING. Briefly, it is the old Miles Aerovan box-car freighter fitted with a Hurel-Dubois high-aspect-ratio wing to improve take-off and climb and, particularly, single-engine performance. Although the long thin wing may appear unfamiliar to some spectators at Farnborough, this French invention has now been thoroughly proved in development flying in France over a number of years. The Miles company have been impressed with its economical possibilities and have formed HDM Aviation Limited in conjunction with Avions Hurel-Dubois, to exploit its use in the United Kingdom.

ACCOUNTANT

Making its first public appearance is the new Accountant propeller-turbine transport aircraft developed by Aviation Traders (Engineering) Limited, 21 Wigmore-street, London, W.1. The manufacturers foresee two principal rôles for the Accountant—as a feeder-liner, and as an executive aircraft. In the feeder liner rôle, the Accountant is assured of a future, since the manufacturers—who are primarily a maintenance and modifications engineering organisation, and are therefore likely to be biased towards "design for maintenance"—are closely linked with an operating company, Air Charter Limited, who will be adding Accountants to their fleet as soon as certification is completed.

The Accountant, which is powered by two 1,730 h.p. Rolls-Royce Dart engines, is a rugged machine intended primarily for the smaller operating companies who mostly do not have the comprehensive base facilities of the scheduled airlines. With a take-off weight of 28,500 lb., it will carry 28 passengers and baggage at a cruising speed of 265 knots over a stage distance of 750 statute miles, allowing for fuel reserves for instrument flight conditions; with full fuel tanks (1,280 Imperial gallons) and the same reserves, the maximum stage distance is over 2,000 statute miles, and some 14 passengers can be carried.

A take-off field length, in standard-atmosphere sea-level conditions, of 3,220 ft. is required for the Accountant, and the initial rate of climb is 1,500 ft. per minute or, with one engine out of action, 500 ft. per minute. The principal dimensions are: span, 82 ft. 6 in.; length, 62 ft. 1 in.; height, 25 ft. 3½ in.; wing area, 632 sq. ft.; aspect ratio, 10·77; track, 21 ft. 8·3 in.; wheelbase, 12 ft. 8 in. The total cabin capacity is 1,620 cub. ft.

The cabin is pressurised to a maximum of 5½ lb. per sq. in. above ambient, giving a cabin atmosphere of 8,000 ft. at a height of 25,000 ft. A fatigue-test specimen fuselage complete with wing centre section is under construction and will be tested in the Royal Aircraft Establishment's water tank. The fuselage is simple, the centre portion of the production version being of parallel section, which can easily be lengthened to seat up to 40 passengers. The wing box structure is made up of five assemblies, the centre section including the engine mounting points, the inner wings embodying four integral fuel tanks (two each side), and the outer wings. The slotted flaps extend from aileron to aileron, and are double-slotted outboard from the fuselage sides, and hydraulically actuated, as are also the tricycle undercarriage retraction mechanism, the nose-wheel steering and the brakes. The electrical system comprises a 28 volt direct current supply for general services, 208 volt alternating current for engine de-icing, and provision for rotary inverters to supply 115 volt a.c. for flight instruments, auto-pilot, V.O.R./I.L.S. and cloud and collision warning radar.

NEAR-PROTOTYPES

Transport aircraft now under construction that are represented in the static exhibition include the 82/102-seat Vanguard airliner, which will be powered by four Rolls-Royce Tyne propeller turbines, being built by Vickers-Armstrongs Limited, Weybridge, who are showing a full-size nose mock-up complete with instruments, controls, and cockpit furnishings, of the type destined for Trans-Canada Air Lines; and a model of the Freightercoach being made by Sir W. G. Armstrong Whitworth (Aircraft) Limited, Baginton, Coventry, which is to be of the twin-boom box-car type for use as a freighter or car-ferry aircraft, capable of carrying bulky payloads up to 28,000 lb., or as a "coach" type passenger aircraft seating some 80 passengers. This is yet another aircraft to be powered by Rolls-Royce propeller turbines—the initial version with four Darts, but with the possibility of a twin-Tyne aircraft later. Shown in the accompanying illustration is a complete fuselage section, without windows, and with domes fitted at either end for pressurisation test, which will shortly undergo repeated pressure tests in Armstrong Whitworth's water tank—the same tank in which the Apollo fuselage was tested as long ago as 1949 when it withstood 38,000 pulsations, each simulating one flight cycle. A larger water tank to take the complete aircraft will come into operation at the company's Whitley works next year.

LAMINAR FLOW PROJECTS

Not yet beyond the design stage is the Handley Page Civil Victor 172-seat airliner for medium range routes, for which four Rolls-Royce Conway by-pass turbojets are envisaged as power units. This aircraft would carry a payload of nearly 18 tons at a cruising speed of over 600 m.p.h.

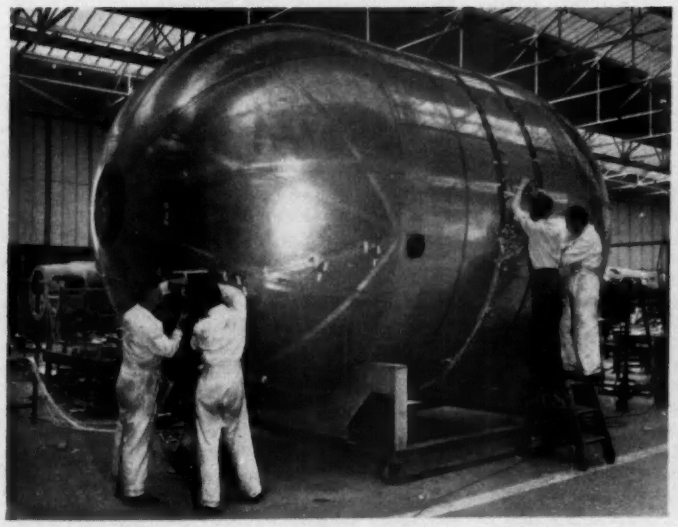
Of greater technical interest, however, are the Handley Page company's researches on laminar flow applied to long-range transport aircraft. They claim that, by using engine power to alter the airflow over the lifting surfaces of an aircraft, large drag reductions—up to about 40 per cent. in some cases—can be obtained at an expense of a weight increase of some 2 per cent. of the all-up weight. A smooth boundary layer is maintained by sucking part of it away through porous or perforated wing surfaces, and expelling it into the atmosphere so as to leave as little wake disturbance as possible. Engineering investigations have been carried out on the layout and materials of suction surfaces and the best way of integrating them with the structure to save weight; on pumping and methods of controlling airflow within the suction system. Flight tests have been carried out using an aerofoil "glove" on a Vampire wing. In addition, a series of design studies has been completed for a family of laminar-flow transport aircraft for various ranges and cruising speeds.

A great disparity between cruising power and that required for take-off and in the climb is characteristic of laminarised aircraft. It may thus be necessary to have some power units—whose main virtue would be fuel economy—for use during all stages of flight, and to supplement them during take-off and climb by light auxiliary engines of high thrust/weight ratio. By-pass engines may be the answer; they are economical in fuel consumption and can permit an aircraft to cruise at low engine speeds, unlike other jet engines. They can thus be throttled back for cruising after providing additional power for the climb. Because their superiority lies in the greater distance they can fly for a given weight of fuel, laminarised aircraft show to the best advantage over longer ranges.

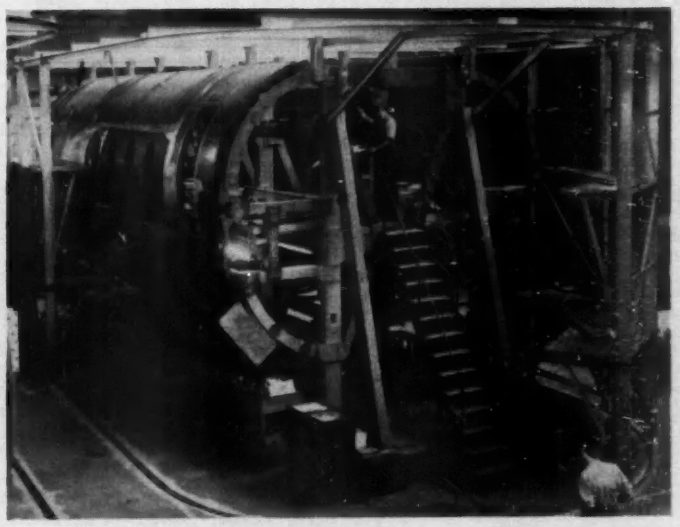
One of the more ambitious Handley Page studies envisages an aircraft cruising at Mach 0·9 capable of flying non-stop from Britain to Australia with 120 passengers, a possibility of considerable strategic significance to-day. It would have a highly-swept wing and be powered by four Rolls-Royce Conway engines—each of 16,320 lb. static thrust—in underslung pods. Direct operating costs, it is estimated, would be slightly under one shilling a short ton statute mile. The leading particulars of the project are: span, 220 ft.; all-up weight, 300,000 lb.; payload, 30,000 lb.; take-off to 50 ft. (sea level, standard atmosphere), 6,000 ft.; cruising speed, 592 m.p.h. at 45,000 to 55,000 ft.; still-air stage length (30,000 lb. pay-load), 12,100 miles; landing from 50 ft. (sea level, standard atmosphere), 4,100 ft.

The Accountant propeller-turbine feeder liner is designed for rugged usage.

The HDM.105 transport has a high-aspect ratio wing.



A fuselage test section of the Freightercoach will shortly undergo repeated pressure tests.



The Vanguard propeller-turbine airliner fuselage is now under construction at Weybridge.

THE NEW POOR: NEED THEY ALWAYS BE WITH US?

It was to be expected that Professor P. M. S. Blackett, in his presidential address to the British Association, should take a topical subject as his theme and that he should not shirk its philosophic and political implications, however controversial. He delivered a "lay sermon," as he said, on the immorality and political inexpediency of the expanding gap in the division of power and wealth possessed respectively by the industrialised and the underdeveloped nations of the world, and of the wide differences of health and comfort enjoyed by their peoples.

Excluding the countries within the Soviet orbit, there are 400 million people in the highly industrialised countries of Europe, North America and Australia with an average income a head, at 1949 prices, of £300 a year. At the other extreme are the still pre-industrial countries, particularly those of Asia, Africa and South America which, excluding Soviet China, have a population of some 1,000 million people and an average income of £20 a year a head. This enormous gap is widening: whereas the productivity and wealth of the West have been rising so as to increase incomes at the rate of around 2 per cent. a year, those of the Eastern countries have remained nearly static for the last 300 years. New technological advances, involving as they do very expensive capital equipment, are tending to accelerate the pace at which this is taking place.

It is to the reasons for this phenomenon that Professor Blackett devoted a large part of his address, and there is no doubt that a truly scientific explanation of what, so far, has never been adequately explained, would be of great interest and certainly of considerable practical value. The proximate causes of the different rates of economic expansion are clear enough: some two hundred years ago the Western countries, lead by Britain, "took off" into a period of sustained economic growth. Previous to that time their standards of living were probably no higher than those of the East and their technological methods were no more advanced than, and in many cases had been acquired from, older civilisations such as the Chinese. Little improvement took place in the material arts between the height of the great Middle and Far Eastern Empires and the rise of modern technology in Europe about the Eighteenth Century.

GROWTH BREEDS GROWTH

Once the process has been started it proceeds at a cumulative rate, with savings and gross investment rising until some 15 per cent. of national incomes become available for gross investment to continue the process. In the typical pre-industrial country, wealth tends to remain constant or rises slowly, so that savings and investment are low and barely sufficient to maintain a static economy by paying for the depreciation of existing wealth. In the industrial country growth breeds growth and the interest in technological change stimulates and is stimulated by scientific discovery, itself following a pattern of cumulative advance.

What causes a static economy suddenly to become "air-borne"; or, to change the metaphor to one Professor Blackett did not use, what is the exact nature of the mutation which causes such a sudden growth in the social organisation and what is its cause? The answer will not be found in the thinking of any single academic discipline; nor in the mere co-ordination of ideas from the natural and social sciences. What one might have expected from Professor Blackett on this occasion was a philosophic integration of current knowledge which enlarged our understanding of the historical process which we are witnessing; and, in spite of the great interest of what he had to say and his undoubted earnestness, this he failed to produce.

He reminded us that the essential pre-requisite for the scientific advance which accompanied the Industrial Revolution was the weakening of the opposition of organised religion to the free play of scientific experimentation and speculation. It was then the social revolution which followed the Civil War in Britain which freed the cities and merchants from the shackles of a still feudally inclined monarchy and aristocracy; so that Britain became the first nation free from restrictions both on scientific thought and on the use of money for profitable and speculative investment. It is not clear why this should have happened in north-west Europe and not in China or India, or, for that matter, in Spain. Professor Blackett admits that it was Western superiority in the pre-scientific technology of firearms and ocean-going ships which enabled Europe to conquer most of Asia and America before the scientific revolution began; although the only explanation for this superiority which he gives is that "Europe was then passing through one of those periods of intense and ruthless energy, both mental and physical, which occur, for complex reasons, from time to time in the history of mankind."

It is a pity that he excluded from this survey what has happened in Russia, where industrialisation was commenced under the feudalism of the Tsars and has been accelerated and completed under the dictatorship of the Communist Party. A survey of the motives which lead to industrial change in both eras and of the varying reactions to it of the different peoples, some Eastern, some Western, of the vast Union of Soviet Socialist Republics might have thrown some light on the problem of inherent tendencies in societies rendering them more or less capable of making sudden and rapid changes in their way of life.

AFRICAN TRIBES

So far science, as Professor Blackett admits, has little to say of the innate mental differences between the different races of mankind and, even if it had, no agreement would be obtainable on the relative weight to be attached to the various abilities. He points to the artistic and technical triumphs during the Middle Ages of Peru, Mexico, India, Indo-China and China as a perpetual reminder of the creative ability and immense energy which have been characteristic of their diverse peoples in quite recent times. It would have been interesting if he had also said something of the many African tribes who, although apparently capable of acquiring most modern skills if suitably taught, have not themselves discovered even the wheel, the plough or the loom. Geographical factors, particularly climate and nearness to the sea, which affect not only individual physique and personality but also social and economic organisation, cannot be ignored.

Nevertheless he is convinced that Western pessimism about the possibility of social advance by ex-colonial Asian countries is both unjustified in fact and a serious cause of practical errors. It has led the West to overestimate the need of the have-not countries for technical advice from Western experts and to underestimate the need for simple financial help. In so far as expert aid by Western technical personnel is needed, he believes that it is usually both more efficient and cheaper to provide money for an underdeveloped country itself to hire those whom it needs; though this begs the question of the willingness of suitable qualified Western staff to undertake this work. The amount of financial help needed to have any recognisable effect would be an additional £1,000 million a year as a free gift or long-term loans.

If this were provided by the 400 million Western donors to the 1,000 million Asians, Africans and South Americans in the underdeveloped countries outside the Soviet orbit, it would amount to a levy of less than 1 per cent. of their income; although Professor Blackett does not point out that this would make a very different impact on the economy of the United States than, say, that of Italy. Britain's share would be £150 million a year, a figure already proposed by Mr. Gaitskell, and it would only postpone by a year the expected rise of 50 per cent. in British living standards over the next quarter of a century. To the recipient peoples it would mean £1 a head a year in foreign exchange or a 5 per cent. addition to their total incomes. If wisely invested, he estimates that this should allow their standard of living to rise at rather more than 2 per cent. a year.

It is not because of any disagreement with Professor Blackett's opinion about the need to help these countries, but in order to make clearer the nature of the problems to be overcome that it is worth while examining the assumptions behind these figures. The 50 per cent. rise in the British standard of living over 25 years is just half the figure usually mentioned and thought, by competent economists, to be attainable given reasonable economic policies. But if one were to split the difference the resultant 75 per cent. would still be higher than the 65 per cent. which the underdeveloped countries would reach if they were able to achieve the, for them, phenomenal rate of increase of 2 per cent. a year. A crude examination of the figures makes the task these countries face seem not only Herculean but positively Sisyphian: however much they struggle up the slope towards parity with the industrialised nations, the further away the level reached by the latter recedes.

COMMUNIST ALTERNATIVE

Must they, therefore, succumb to the theories of the Communists and sacrifice a generation or two as the manure by which the crops of the future are to be fertilised; generations whose standard of living, instead of rising, has to be reduced in the interests of investment in the industries whose products their grandchildren may enjoy? The answer lies partly in the timescale. There is no magic in quarter or half centuries. What is needed is that desperately poor people should feel that some improvement is continuously taking place in their conditions and that there are signs of hope for the future: but this itself exposes the inadequacy of the methods of measuring standards of living and of comparing standards of comfort and enjoyment. If these are to be measured in terms of the wants felt and the goods received by urban industrial workers in modern Britain or the United States, then only despair and envy can result.

It is not to fall into the hypocritical attitude against which Professor Blackett warns us, of the rich preaching the virtue of poverty to the poor, to suggest that there may be newer and simpler ways of providing good standards of physiological and psychological comfort, particularly in tropical areas, than those developed in the temperate West. The Indians are leading the way with their Community Development Schemes and engineers are helping by the development of means of producing electricity in small, local plants, operated by solar energy or small steam engines, which may well be much cheaper than vast hydro or nuclear stations with their inevitable long transmission lines.

There is surely a big field for research, both technological and sociological, into ways of improving the living conditions of the millions now living at subsistence levels, which can take advantage of new knowledge in the natural and social sciences, in engineering, in building and in agriculture. In this way, whatever resources become available to the under-developed countries can be used to provide not only an industrial base for the future, but also some alleviation of hardship for the present. The speed at which both can take place will depend, as Professor Blackett rightly warns us, on our willingness to make some sacrifice of our own rate of increase

and, in the democracies, it is for each individual to make up his mind how morally right or politically necessary such a policy would be.

The gap between wealth and poverty among the peoples of the world exists, it is growing greater and, related as it is to questions of race and colour, it is becoming the major cause of world tension and instability. It is a problem to which both money and thought need to be continually devoted.

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Obituary

SIR CYRIL KIRKPATRICK

It is with regret that we have to record the death of Sir Cyril Kirkpatrick, at the age of 84. Sir Cyril was formerly chief engineer to the Port of London Authority during a period when the docks increased greatly in size. He died at his home on Sunday, August 25.

Born in 1872, Cyril Reginald Sutton Kirkpatrick was educated at Repton and then at the Crystal Palace School of Engineering before becoming a pupil of Mr. E. B. Thornhill, chief engineer of the London and North Western Railway. Then followed a period of 10 years during which he worked for a number of contractors, almost wholly on railway construction and culminating with the King Edward VII Bridge which carries the North Eastern Railway over the River Tyne. His connections with Newcastle were continued when, in 1906, he accepted the post of city engineer there.

In 1910 he came south to London to become chief assistant to Sir Frederick Palmer, chief engineer to the recently formed Port Authority. Together they drew up the plans for the great extensions and improvements to the docks, particularly at Tilbury and at the Albert Dock. When Sir Frederick resigned in 1912, Kirkpatrick took over and saw through the construction programme that had been planned, including the King George V Dock which was opened in 1921. A year later his efforts were recognised by the award of a knighthood.

He resigned from the Authority in 1924 and began practising in Westminster. Among the work for which he was responsible are to be included the foundations for the power station at Ford's Dagenham works and port works at Galway and Maryport. He was a member of the Central Rhine Commission (1934) and of the International Consultative Commission of the Suez Canal Company (1935-53), as well as consulting engineer for the port of Alexandria.

During the war, he supervised the construction of 33 caissons for the Mulberry Harbour.

He became an associate member of the Institution of Civil Engineers in 1898 and was transferred to full membership in 1909. He served as president in 1931-32.

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AN INTERVIEW WITH KAPITSA

The statements which the Soviet Government have made about their inter-continental ballistic missile suggest that Russian engineers have great technical abilities—at least those of them who work on the super-priority jobs. But what is the quality of Russian engineers generally? (We have heard a lot about the numbers that they have trained in the past few years.)

Mr. E. P. Ward, M.A., A.M.I.Mech.E, a deputy editor of ENGINEERING, has now returned from the U.S.S.R., where he visited research and engineering establishments to find the answer to this question. He talked, in their own language, to many directors of factories, scientists and Government officials, and he had an interview with Academician P. I. Kapitsa, the best-known Russian scientist, who worked with Lord Rutherford at Cambridge more than thirty years ago.

Mr. Ward's reports will be published in ENGINEERING, commencing in next week's issue.

Companies in the News

A.E.I. at the Half Year

Addressing shareholders in April, Lord Chandos, the chairman of Associated Electrical Industries Limited, said that the second half of 1957 should show the beginnings of a return on heavy capital investment recently completed by the group. For this reason he was reluctant to take 1956 as a reliable guide to potential earning capacity. There has been an unusually large influx of orders in the early part of 1957, the order book was in a healthy state and capacity would be employed at a high rate for at least the next year or two.

Results for the first half of 1957 were published last week. So far as the group is concerned, they are very satisfactory, but they hint at the growing problem throughout the engineering industry of rising costs and falling profit margins. In view of the chairman's remarks in April, it is reasonable to expect that the improvement in the first half of this year compared with the second half of 1956 will be continued. The value of output fell from £72 million to £67·9 million over these two half-years, but orders received at the end of June, 1957, at £84·5 million were substantially higher than at the end of the two previous half-years. It has to be remembered that the latest figures cover the period of the engineering strike which checked the rise in production and involved substantial losses for the group. The results are thus exceedingly satisfactory. For the future, Lord Chandos has already expressed confidence about the short-term outlook and the recent boom in consumer expenditure will probably further assist the group which, although its interests are highly diversified throughout electrical engineering, has substantial interests in household electrical equipment.

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Chemicals' Progress

The information given by Sir Henry J. Ross in his recent speech to the shareholders of the Distillers Company on his company's activities in the chemical field suggested continued growth in demand (and capacity), "although in many markets trading conditions tend to become increasingly competitive." The interim reports of two chemical companies for the six months to June 30 tend to confirm this. Both are expanding companies who have still some way to go to complete their development programme. Their results are satisfactory without being startling.

Sir Miles Thomas, chairman of Monsanto Chemicals, reports a 14·4 per cent. increase in turnover compared to the first six months of 1956, though gross income before tax was only about 10 per cent. higher. His comment, that "keen competition and increasing costs are limiting the benefits the company should derive from increased volume," applies also to Albright and Wilson. In their case the slight fall in trading profit for the six months (£2·23 million against £2·29 million) cannot easily be assessed, because Oldbury Electro-Chemical, whose results are included in the 1956 figure, are no longer members of the group. The directors' comment, that the reduction of profits due to this "has been more than offset by the improved results of the rest of the group," suggests that their company has done well, but perhaps not as well as they would have expected from the considerable investments in new capacity and modern plant.

Reports from plant makers suggest that the great expansion of the chemical industry is far from completed. In the field of petroleum chemicals particularly, the rate of growth is rising still. On the other hand world capacity has, for some months now, been catching up with demand. The result is keener competition and greater pressure on companies whose plant or processes are not up to date. The return of competitive conditions should, as it has done in shipping, lead to a continued heavy demand for the most modern plant and equipment.

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English Electric Flies High

For some few years now, the pilot of a Canberra aircraft has been the holder of the world altitude record for aeroplanes—but until last week the pilot concerned was Mr. Walter Gibb of the Bristol Aeroplane Company, Limited. On August 28, one of the English Electric group's own pilots—Mr. Michael Randrup of the Napier Flight Development Establishment—broke Mr. Gibb's record and attained a height of 21,336 metres (70,000 ft.) (subject to confirmation by the Fédération Aéronautique Internationale), in a Canberra flying test-bed on which Napier's Double Scorpion rocket engine is undergoing development trials. The record-breaking aircraft and engine are on view at Farnborough this week, and the Double Scorpion is described elsewhere in this issue.

To raise the critical Mach number, which at this height is not so very far above the stalling speed, the Canberra aircraft has been fitted with vortex generators on the wing and the base of the fin. The margin between the stall and the critical Mach number when the Canberra reached 70,000 ft. was about 15 m.p.h.

In the record flight, the initial climb to 44,000 ft. was carried out on the two standard Rolls-Royce Avon turbojets. The aircraft was then dived for a short distance, and then put into a climb, when the Double Scorpion was brought into action. The rocket was shut down at 70,000 ft., with propellant still available. Practically all the thrust which carried the aircraft to the record height came from the rocket, the Avons being kept in operation to provide power for the electrical, hydraulic, and pressurising systems. To guard the crew from the fatal effects of cabin pressure failure, a new type of pressure clothing was used. To measure the altitude accurately, a radio altimeter was used—for the first time in a record attempt—and the readings were filmed during flight.

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Budgeting for Development and Research

In many branches of engineering to-day mobilising large financial and technical resources is the key to success. The big prizes tend to be taken by the big battalions. This is a generalisation which can be taken too far for there is still scope for enterprise by small groups and individuals of technical and commercial acumen, but the manufacturer of large plant needs big resources to develop and produce his equipment and much of his success depends on his ability to stay out in the forefront of the development of a wide range of techincal matters.

A recent example of this comes from America where the advantages if not the virtues of bigness are fully appreciated in certain engineering fields. The Allis-Chalmers Manufacturing Company has recently begun work on a new engineering development and research laboratory which is to cost about £1·17 million. This project is connected with the expansion of the company's Harvey works in Illinois. Construction of the buildings is to begin at once and the completion date is early in 1958. The major structures include a central engineering building, an engine and materials-handling laboratory and an engine-test wing accommodating 32 engine dynamometers. The money is not only very substantial but it is clearly going to be spent in a hurry.

Plant and Equipment

THE ENGINEERING EXHIBITION

Second Article

Now entering its second week, the exhibition was officially opened by Sir Christopher Hinton. A few more of the things to see are described in this article.

I.C. Engines

GASIFIERS

One of the members of the Brush Group—the National Gas and Oil Engine Company, Limited, of Ashton-under-Lyne—is exhibiting one of the first British-built gasifiers, made under licence. A G.S.34, it has a gas horse-power rating of 1,232 which is equivalent to approximately 1,000 shaft horse power for marine propulsion duties. Apart from the lubricator, all parts were made at Ashton and, moreover, were made from production tools so that the factory is fully set up to produce these units in quantity. One of this make is illustrated in Fig. 26. Smith's Dock Company, Limited, South Bank, Middlesbrough, are also showing a British-built G.S.34 on a group stand of the Pescara licensees. Yet another firm showing this model is the Free Piston Engine Company, Limited, 34-37 Bedford-row, London, W.C.1, a member of the Associated British Engineering Group. In addition to the G.S.34 that they are showing on the stand, they have as an outside exhibit a completely self-contained generating set made up of a 350 s.h.p. C.S.75 gasifier coupled to a 200 kW d.c. Allen generator through a seven-stage Budworth turbine and reduction gearing.

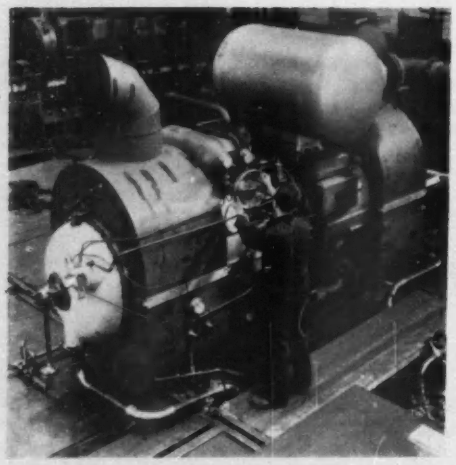

Fig. 26 A free-piston gasifier developing 1,232 gas horse-power. National Gas and Oil Engine Co., Ltd.

Fig. 27 Turbine unit for use with a free-piston gasifier. Brush Electrical Engineering Co., Ltd.

FREE-PISTON TURBINE

Designed specifically for use with the free piston gasifiers that are now being made in this country is a range of gas-turbines by the Brush Electrical Engineering Co., Ltd., Loughborough, and shown on the Group stand. The smallest is for use with a single G.S.34 gasifier and has a normal rating of 1,000 h.p., and the largest for ten gasifiers in parallel having, therefore, a rating of 10,000 h.p. Since the working conditions approach nearly to those existing in a steam turbine, the company has been able to use its experience in this field to advantage. Entry conditions are approximately four atmospheres at 450 deg. C. and therefore the units are of the multi-stage axial type with reaction free-vortex blading. A volute form for the intake casing reduces parasitic losses and a diffuser is fitted to the blade exit annulus. One model is shown in Fig. 27.

250 H.P. GAS-TURBINE

One of the exhibits on the stand of Auto Diesels Limited, Uxbridge, Middlesex, is a 2·26 litre STAD low-speed industrial Diesel power unit developing 31 b.h.p. at 2,000 r.p.m. on the 12-hour rating. Another is a gas-turbine alternator set incorporating the STAD gas-turbine driving a Crompton-Parkinson 175 kVA alternator. The all-radial flow gas-turbine is a single-stage two-bearing unit carrying a centrifugal compressor and a radial inward-flow turbine mounted back to back on a cantilever main shaft. The design is symmetrical about the turbine axis. The reduction gear and the auxiliary drives are housed in a rigid one-piece light-alloy casting. Twin layshafts are used to reduce the load on the high-thrust bearing and the final drive emerges centrally from the rear face of the casting, carried by a pair of taper roller bearings. Twin high-heat release single reverse flow combustion chambers are used fitted with simplex atomisers and situated in the flow path between the compressor and turbine. Any gaseous or distillate fuel can be used. The turbine is governed to B.S. 649 and is rated at 250 b.h.p.

MULTI-PURPOSE GAS-TURBINE

The English Electric Company, Limited, Marconi House, Strand, London, W.C.2, is exhibiting the EM27P industrial gas-turbine.

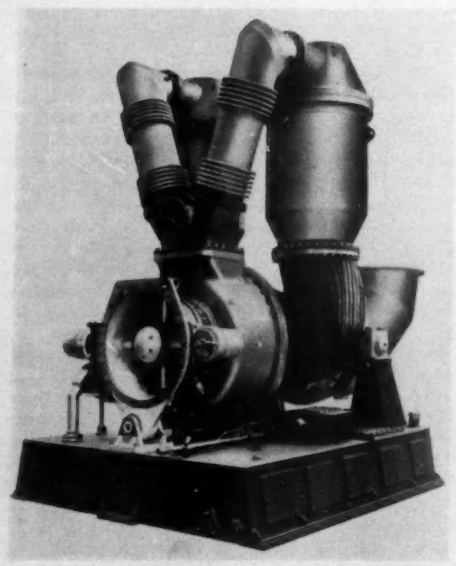

Fig. 28 The EM27P industrial gas-turbine develops 2,750 h.p. at 7,000 r.p.m. when fitted with a heat recuperator. English Electric Co., Ltd.

MARINE, WELDING AND NUCLEAR ENERGY

Things to See at Olympia

Described in this Issue

GASIFIERS
National Gas and Oil Engine Co., Ltd.
Smith's Dock Co., Ltd.
Free Piston Engine Co. Ltd.

FREE-PISTON TURBINE
Brush Electrical Engineering Co., Ltd.

250 H.P. GAS-TURBINE
Auto Diesels Ltd.

MULTI-PURPOSE GAS-TURBINE
English Electric Co., Ltd.

TURBINE BLADES
C. A. Parsons and Co., Ltd.

SINGLE-STAGE TURBO-CHARGER
Brush Group

TWO DIESEL RANGES
W. H. Dorman and Co., Ltd.

NATIONAL DIESELS
National Gas and Oil Engine Co., Ltd.

RAILWAY DIESELS
North British Locomotive Co., Ltd.

INDUSTRIAL AND MARINE DIESELS
Leyland Motors Ltd.

PUNCHING, SHEARING AND CROPPING MACHINES
Henry Pels and Co., Ltd.

PLATE AND SHEET METAL WORKING
Bronx Engineering Co., Ltd.

CONTINENTAL MACHINES
Press and Shear Co., Ltd.

MACHINING HARD MATERIALS
Kerry's (Ultrasonics) Ltd.

HYDRAULIC PUMPS AND PRESSES
Fawcett-Finney Ltd.

COMPRESSORS
Worthington-Simpson Ltd.

PORTABLE ROTARY COMPRESSORS
Broom and Wade Ltd.

COMPRESSED AIR EQUIPMENT
Shipston Engineering Co., Ltd.

PNEUMATIC EQUIPMENT
Holman Brothers Ltd.

POWER VANE COMPRESSORS
Consolidated Pneumatic Tool Co., Ltd.

AIR TOOLS
Atlas Copco (Great Britain) Ltd.

TRANSPORTABLE X-RAY UNIT
Marconi Instruments Ltd.

ULTRASONIC ANTI-FOULING
Marconi International Marine Communication Co., Ltd.

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To be Described in Subsequent Issues

Other notable items include cathodic protection shown by Cathodic Corrosion Control Limited; welding positioners by Courtburn Positioners Ltd.; balancing machine by W. & T. Avery Ltd.; hydraulic jacks by Tangyes Ltd.; ultrasonic engraving by Mullard Ltd.; leak detection by B.T.H. Co. ; scale-free heating by the Gas Council; special duty pumps by Harland Engineering Co. Ltd., Mono Pumps Ltd., Hamworthy Engineering Ltd. and K.S.B. Export G.m.b.H.; and a marine version of the Bristol Proteus gas-turbine.

The standard unit is being shown, equipped with the optional exhaust-heat recuperator. Displayed separately on the stand are the charging set rotor—the compressor and its driving turbine—and the power turbine rotor, from another EM27P engine.

A two-shaft, open-cycle machine of fully cooled kinematic construction, the EM27P gas turbine is designed for long service life, light weight, small size and quick-starting characteristics. The nominal continuous rating is 2,750 h.p. at 7,000 r.p.m. when operating with a heat recuperator (Fig. 28) and 2,950 h.p. at 7,000 r.p.m. in non-recuperative form; operation is possible over a wide range of output speeds with only relatively small changes in rated output and efficiency. Suitable fuels include distillate and certain low-ash heavier oil fuels, natural, oil refinery and many other combustible gases. Dual-fuel versions (gas/oil) enable the turbine to be changed over to operation on oil fuel in the event of a breakdown in gas supply. The turbine is in batch production.

The EM27P compressor has six axial stages followed by one radial stage; the overall pressure ratio is 4·8 to 1. Air leaving the compressor is ducted either direct, or via the heat recuperator, to the twin all-metal louvred-wall combustion chambers. The gases leave the combustion chambers at 1,430 deg. F. (777 deg. C.) and enter the turbine inlet casing prior to expansion through the mechanically separate compressor driving and power turbines. These are arranged in series, each having two axial stages.

The compact single-pass contra-flow heat recuperator fitted to the turbine displayed is available as an optional extra. Of all-welded stainless-steel construction, this will reduce specific fuel consumption by some 23 per cent. at the expense of a slight drop in power output. Forming an integral part of the gas turbine assembly, the addition of the heat recuperator does not materially increase the overall dimensions of the engine.

TURBINE BLADES

The central exhibit on the stand of C. A. Parsons and Company, Limited, Newcastle-upon-Tyne, is a completely bladed low-pressure turbine shaft for one of the 23 MW turbo-generators that the company are supplying to the Calder Hall and Chapelcross nuclear power stations. This is to be seen in Fig. 29 above. There are also photographs and drawings of 60 and 200 MW sets under construction. Another exhibit is of examples of the type of blading used in these large high-pressure high-temperature machines both at the inlet end and the exhaust end. At the inlet end the blades are produced by rolling methods and are integral with their roots and shrouds. For convenience in handling, the blades are formed into short segments which are serrated along the root portion and secured in serrated grooves in the rotor by means of side locking strips. For the exhaust end blading the blades are rolled integral with their roots and for the last one or two rows of rotor blades the side entry form of root fixing is adopted. These blades are highly tapered and twisted and are of vortex free design.

SINGLE-STAGE TURBO-CHARGER

A turbo-charger exhibited by the Brush Group is rated for 4,000 cub. ft. per minute at a pressure ratio of two to one. It consists of a single-stage centrifugal compressor mounted on a common shaft with a single-stage axial-flow exhaust-gas turbine and housed in casings which duct the air and gas flows to and from the engine. The units are designed so that turbine blade heights, nozzle areas and diffuser areas can be altered to match the turbine to the engine within the range of each frame size. Both turbine and compressor casings can be arranged in a number of different ways to suit engine installations, but the turbine bearing housing and intake bearing are always mounted vertically in order to allow correct oil drainage. Three-ply oil-wetted air filters and also intercoolers are available for the different sizes.

TWO DIESEL RANGES

For the first time the whole range of the L series of Diesel engines made by W. H. Dorman and Company, Limited, Stafford, are being exhibited together. The series includes two, three, four, five, six and eight cylinder models, and the two, five and eight are on view for the first time. The power range is from 20 to 160 h.p., normally aspirated, or to 200 h.p. when supercharged. Points of special interest with these engines are the interchangeability of the parts and the use of Unified screw threads throughout. The bore and stroke are 120 mm. and 130 mm. respectively. Fuel consumption is in the region of 0·38 lb. per b.h.p. hour at the maximum torque (300 lb.-ft. for the five cylinder model, 525 for the eight) achieved at a speed of approximately 1,200 r.p.m.

At the Exhibition, Dorman's are also introducing their Q range of engines by displaying the 6QA six cylinder model in normally-aspirated form. Bore and stroke are 6·25 in. and 6·5 in. respectively. This engine, which is illustrated in Fig. 30, has a power range from 100 b.h.p. at 800 r.p.m. to 262·5 b.h.p. at 1,800 r.p.m. and an increase to 2,000 r.p.m. is planned when the power would be 287·5 b.h.p. When supercharged the power is increased to 390 b.h.p. at 2,000 r.p.m. The range will ultimately include five, six, eight and twelve cylinder versions in both in-line and V-form, giving a range of power from 85 to 700 b.h.p. In common with the L and K ranges, this series will embody Unified screw threads throughout, and standard parts will be used as much as possible. As an alternative, the five and six cylinder versions will be available in a horizontal form, and all models can be either mechanically or turbo blown.

NATIONAL DIESELS

A horizontal version of a new range of vertical and horizontal Diesel engines is being shown by the National Gas and Oil Engine Company, Limited, Ashton-under-Lyne. Six and eight cylinder models are made with continuous power ratings from 164 h.p. at 1,000 r.p.m. to 533 h.p. at 1,500 r.p.m. with a top limit of 660 h.p. at 1,800 r.p.m. At present, normally aspirated and mechanically supercharged designs are available in both vertical and horizontal versions, but the turbo-charged and high-pressure turbo-charged models are as yet available only in the vertical form. These engines will be known as the NM series and the six-cylinder model at the Exhibition is shown in the illustration, Fig. 31.

RAILWAY DIESELS

Newcomers to the Exhibition are the North British Locomotive Company, Limited, Glasgow, N.1, who have taken a stand for the first time. They are showing a comprehensive range of their products including examples of the well-known Voith-North British hydraulic transmission. The L36r unit is incorporated in the 625 h.p. locomotives supplied to the Indian Railways (Western) for use on the Deesa-Kandla metre-gauge line. A model of one is being shown. The locomotives are of the B-B type, the drive being transmitted to all four axles through the hydraulic system and cardan shafts to the axle-mounted gearboxes. The L36r system employs three torque converters, the first for starting, the second for intermediate speeds and the third for high speeds; the operation is fully automatic. Each locomotive weighs 43·3 tons in working order and has a maximum speed of 55 m.p.h. The tractive effort at 25 per cent. adhesion is 24,200 lb.

The company are also showing an L12 V.18/21 engine manufactured under licence from M.A.N. Engines are now in production covering power outputs from 90 to 1,000 b.h.p., the L12 being the largest. On the 12-hour rating the supercharged version will develop 1,100 b.h.p. at 1,500 r.p.m., its weight being 4·25 tons. The crankcase and cylinder block are fabricated in steel and have seven cast-steel bulkheads with

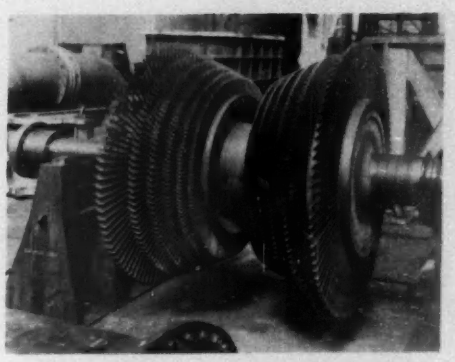

Fig. 29 Low-pressure shaft for a 23 MW turbine. C. A. Parsons and Co., Ltd.

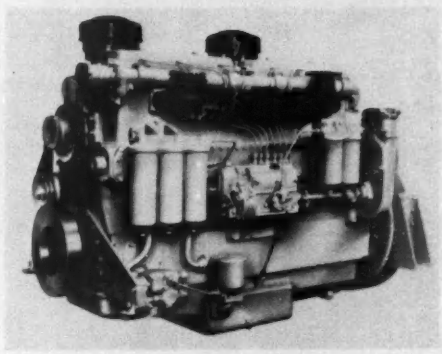

Fig. 30 The 6QA engine develops 262·5 h.p. at 1,800 r.p.m. when normally aspirated. W. H. Dorman and Co., Ltd.

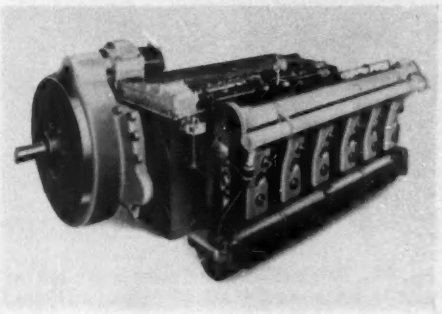

Fig. 31 The six-cylinder model of the NM series is available in either horizontal or vertical form. National Gas and Oil Engine Co., Ltd.

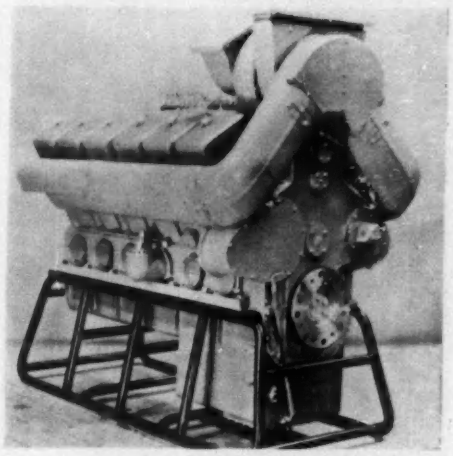

Fig. 32 M.A.N. type engine for main-line locomotives. North British Locomotive Co., Ltd.

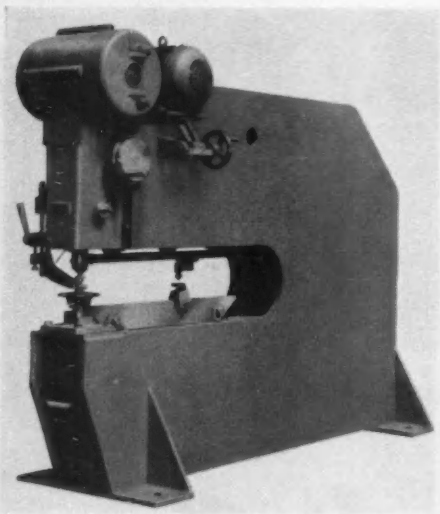

Fig. 33 A new combined machine which shears plates up to $\frac{5}{16}$ in. thick and nibbles up to $\frac{1}{4}$ in. It is equipped with tools for beading, joggling, louvring and dishing. Henry Pels and Co., Ltd.

Fig. 34 This hand-powered press brake can deal with 16 s.w.g. steel sheet, 24 in. long. There is a clearance of 17 in. between the housings. Bronx Engineering Co., Ltd.

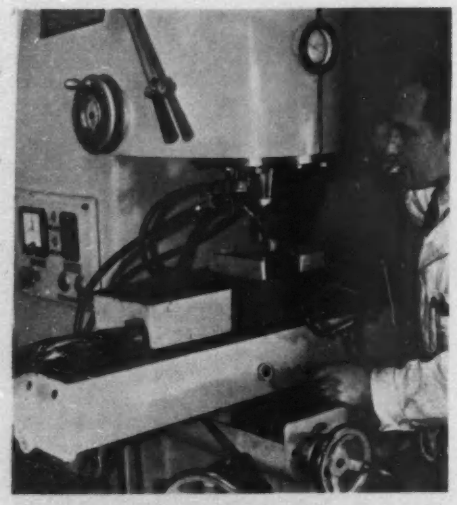

Fig. 35 The ultrasonic drill is finding increasing application as a means of machining brittle or hard materials. Kerry's (Ultrasonics) Ltd.

Continuing Plant and Equipment

steel-plate walls. The entire assembly is stress relieved. Engines of this type are being installed in the main-line locomotives being built by the company under the British Railways modernisation plan, some having hydraulic transmission and some with Diesel-electric drive. One is illustrated in Fig. 32.

INDUSTRIAL OR MARINE USE

Leyland Motors Limited, Leyland, Lancashire, are showing several examples of their industrial engines fitted as power packs or for incorporation in contractors' plant. They are also showing new applications of the 927 cub. in. Leyland-Albion Diesel engine as the drive for a generator set built by Auto Diesels Limited, and as a marine propulsion unit developed by Ajax Marine Engines Limited. Known as the EN 900, the engine is rated at 170/230 b.h.p. and has a maximum torque of 705 lb.-ft. at 1,200 r.p.m. Bore and stroke are 5·5 in. and 6·5 in. respectively. It has renewable wet type liners but in other respects is similar to other engines in the Leyland range. As a generator set the rating is 125 kVA at 0·8 power factor.

As a marine propulsion unit, on the one hour rating it gives 230 b.h.p. at 1,900 r.p.m., and high-duty cast iron has been extensively used to reduce corrosion. Fresh-water cooling is used. Two types of gearbox are available—the MG 165 made by British Twin Disc Limited, supplied in four ratios, or a heavy-duty box manufactured by Self-Changing Gears Limited which is also available in four ratios.

Metal Working

PUNCHING, SHEARING AND CROPPING

Henry Pels and Company, Limited, 32/38 Osnaburgh-street, London, N.W.1, are exhibiting a number of machines for sheet, plate and section cutting and working, including some new models. Their well-known range of universal steel workers is represented by three combined punching, shearing, cropping and notching machines for $\frac{3}{8}$ in., $\frac{1}{2}$ in. and $\frac{3}{4}$ in. capacity respectively, and a combined punching, shearing and cropping machine of $\frac{7}{8}$ in. capacity. A single-ended punching machine, capable of punching up to $1\frac{1}{4}$ in. diameter through $\frac{5}{8}$ in. plate, an 80 ton, 8 ft. press brake and an 8 ft. by $\frac{1}{4}$ in. guillotine shear complete the range of standard machines on show. The Swedish-designed Bevex plate bevelling machine, marketed in the United Kingdom by Henry Pels and Company, is also exhibited. It will bevel the edges of mild-steel plates up to $\frac{1}{2}$ in. thick, or stainless steel up to $\frac{3}{8}$ in., ready for welding, at cutting speeds of up to 11 ft. per minute.

The company's combined high-speed shear and nibbler is newly designed (Fig. 33). It will shear plates up to $\frac{5}{16}$ in. and nibble from the edge or inside the plate up to $\frac{1}{4}$ in. There are 15 stroke settings between nil and $\frac{3}{8}$ in. The top tool can be raised and lowered by hand-wheel while the machine is running, to enable cuts to be started inside the plate, and also to provide sensitive setting of the tool height. It is also possible to rotate the top tool by hand-wheel, with the machine running, so that when shearing or nibbling, cuts can be made in any direction. This is of particular advantage on large plates, which do not have to be moved when the direction of cut is changed. A hand-wheel gives infinitely variable adjustment of the cutting speed of the top tool, while the machine is running, between 650 and 1,600 strokes a minute. The machine is equipped with a circle-cutting attachment, straight edge guide, flanging attachment, and special tools for beading, joggling, louvring and dishing.

PLATE AND SHEET METAL WORKING

Levelling and folding of plate and sheet metal are covered by the machines exhibited by the Bronx Engineering Company, Limited, Lye, near Stourbridge.

Shown for the first time, the Bronx seven-roll levelling machine has a capacity of up to $\frac{1}{2}$ in. thick by 6 ft. wide in mild-steel plate, and is complete with driving and top-roll adjusting motors and electrical control gear. All the rolls are of carbon steel, the three lower ones being $10\frac{1}{2}$ in. diameter, the two centre top ones $10\frac{1}{2}$ in. diameter, and the two outer top ones 9 in. diameter. The top rolls are idle while the lower ones are driven through machine-cut, double-helical steel gears. Simultaneous adjustment of all the rolls is possible, and the two outer top ones have separate setting hand-wheels. Indicators are provided to show the roll settings. The machine has a speed of approximately 20 ft. per minute.

The range of Bronx power-driven press brakes is now supplemented by a hand-operated model of 8 tons capacity, one of these machines being shown in Fig. 34. Specially designed for one-off or short production runs, the press brake can deal with 16 s.w.g. mild-steel sheet over a $\frac{1}{2}$ in. V-opening 24 in. long, and with other material thicknesses in proportion. The top and bottom beams are each 24 in. long, and there is a clearance of 17 in. between the housings. Spring balancing is provided for the top beam, which has a stroke of 2 in., and screw-jack mounting of the bottom beam gives a vertical adjustment over the same distance. Back gauges are fitted as standard. The drive to the top beam is from a crankshaft, with two hand-levers mounted on the right-hand side of the machine. One of these levers, which is keyed direct to the shaft, is used for working on light-gauge materials; the second lever, which operates through a ratchet, is provided for use with heavier gauges.

CONTINENTAL MACHINES

The range of Continental machinery exhibited by the Press and Shear Company, Limited, Hampton-road West, Feltham, Middlesex, includes turret punches, bending and folding machines, screw presses and electro-magnetic presses. Turret punching machines are represented by a 12-station hand-operated model, with punching capacities ranging from $\frac{3}{8}$ in. diameter in steel sheet $\frac{11}{64}$ in. thick to $1\frac{9}{16}$ in. diameter in $\frac{5}{64}$ in. steel. Folding and bending are covered by machines which include the Hera, of 80 in. by $\frac{5}{32}$ in. capacity, to the S. and H. universal edging, folding and round bending machine, which can be used for many different kinds of angular and circular bending work, including closed bends of the tubular type.

Two screw presses from the Hildu range are exhibited, a small open-fronted machine and a larger model of double-sided construction. The former is the power-operated equivalent of a fly press, and is available in several sizes, the approximate pressures being from 6 to 65 tons. Hand or foot control can be used, and the operation of the press is extremely simple, the ram being pushed downwards by the threaded spindle, which is rotated by friction drive from an electric motor on a swivelling bracket. As it rotates to drive the ram downwards the spindle coils up a torsion spring, which provides the energy to return the ram at the end of the stroke. An adjustable depth stop is provided. The larger, double-sided press is of similar construction, but it has a bed and pedestal cast in one piece with the two side columns, which gives great strength and rigidity. It is available in a range of sizes from 10 to 100 tons.

Five electro-magnetic presses from the Elmeg range are on exhibition. These all operate on the same principle, the power head being mounted directly above the ram and controlled by switchgear giving an infinitely-variable force of blow right down to zero. The press can be set for single-stroking or continuous operation as required. One of the presses on show, which are of various capacities from 8 cwt. to $3\frac{1}{2}$ tons, has an 8-station automatic dial feed, with an infinitely-variable time cycle ranging from 0·9 to 4·6 seconds per station.

MACHINING HARD MATERIALS

A 2 kW ultrasonic drilling machine will be exhibited by Kerry's (Ultrasonics) Limited, Warton-road, Stratford, London, E.15. The equipment has recently been improved and the production machining of such materials as germanium, tungsten carbide, and ceramics is now practicable. Recent applications have been the dicing of germanium for transistor manufacture, the cutting of sapphire and agate for instrument bearings, and quartz working.

The cutting tool is of soft material, such as mild steel or brass. It vibrates at 20,000 c.p.s. and an abrasive slurry between the tool and the workpiece cuts out the tool shape in the workpiece. For machining tungsten carbide, hard tool steel, and synthetic jewels, it is necessary to use boron carbide as an abrasive. Glass and some grades of ceramics can be machined quite readily by silicon carbide. Generally the coarser abrasives of about 100-200 mesh are used to provide fairly rapid roughing cuts. For finishing cuts, giving accuracies of about 0·0005 in. and surface finishes of the order 8-10 micro-inches, finer grades of 400-800 mesh are used.

The machine, shown in Fig. 35, has conventional machine-tool table movements and controls. Power is provided by a standard type E7696 low-frequency ultrasonic generator.

This unit is designed for continuous operation. Controls are simplified to give only a tuning control (for matching the generator frequency to the resonant frequency of the tool in use) and a power control. The power consumption is about 5 kVA.

HYDRAULIC PUMPS AND PRESSES

The self-contained hydraulic pump unit can be applied to many types of machine besides the hydraulic press. Examples of both pumps and presses can be seen on the stand of Fawcett-Finney, Limited, Berkley-street, Birmingham, 1, together with various types of hydraulic valve and the Greer-Mercier hydraulic accumulator, the latter being demonstrated also as a pulsation damper. A new hydraulic valve, of the positive-seating type for solenoid operation is also exhibited. It is for either two-way or four-way operation, for oil or water up to 6,000 lb. per sq. in. pressure.

A high-pressure hydraulic power pack is featured by W. H. Marley and Company, Limited, 105 High-road, London, N.11, together with examples of their "Marlco" hydraulic presses, from 12 to 50 tons capacity, and with three ram speeds. The power pack incorporates a Norton high-pressure plunger pump, which will operate continuously at 7,000 lb. per sq. in., the oil delivery being variable at will. A 3 h.p. Brook motor provides the power in the unit exhibited. There is a maximum delivery of 2 gallons per minute at 3,000 lb. per sq. in., or $\frac{3}{8}$ gallon at 7,000 lb. The unit has a screw-type vernier pressure control and a positive shut-off in both directions of flow.

Pilot Works Limited, Bolton, have two new presses on show (Fig. 36), of 12 tons and of 3 tons capacity. The 12 ton machine is a floor-type press with a work table 12 in. square. Daylight is 12 in., and the stroke and throat dimensions are 6 in. and 12 in. respectively. Control is by pedal, with an alternative pressure valve, adjustable from zero to 12 tons. Free downwards travel of the ram is 3 seconds for the 6 in. stroke; 4 seconds are required for the return. A 2 h.p. electric motor provides the power. The 3 ton press is for bench mounting. It is powered by a $\frac{1}{2}$ h.p. motor, with hand lever control, and has a work table 10 in. by $8\frac{1}{2}$ in. With a stroke of $3\frac{3}{4}$ in. the press has a daylight clearance of $7\frac{1}{4}$ in. Free travel speeds are 1 second down and $1\frac{1}{2}$ seconds up. Loaded speed is $\frac{3}{8}$ in. per second.

Air Power

COMPRESSED AIR

The most important trend in compressed-air equipment is, probably, the development of the oil-flooded rotary vane-type air compressor which promises to supersede the traditional reciprocating compressor on account of its smoothness and silent running, its much-reduced maintenance needs and its compact layout. In the field of heavy-duty stationary industrial equipment, the oil-flooded rotary compressor developed by Worthington-Simpson Limited, Newark, is on view for the first time at Olympia although several installations have in fact been in operation for many months. For mining and civil engineering applications, portable rotary compressors have been introduced within the last year both by the Consolidated Pneumatic Tool Company Limited, 232 Dawes-road, London, S.W.6, and by Broom and Wade Limited, High Wycombe, Buckinghamshire.

PORTABLE ROTARY COMPRESSORS

Broom and Wade portable oil-flooded rotary compressors differ from Consolidated's Power Vane (see page 300) in that, in the Broom and Wade machine, the high and low-pressure stages are arranged side by side, the rotors being geared together, and the drive from the engine to the low-pressure rotor is through an internal and external gear-type coupling. The sliding vanes are non-metallic—a feature shared by other new rotary compressors. Again, oil injected into the two rotor casings lubricates, cools and seals the sliding faces against leakage of air. Four sizes of compressor are listed by Broom and Wade, all delivering at a normal operating pressure of 100 lb. per sq. in., the free-air capacities being 120, 210, 250 and 600 cub. ft. per minute. The smallest version is available with 38 b.h.p. Diesel engines of either Ford (Fig. 37) or Petter McLaren (air-cooled) design, or with a 40 h.p. Ford petrol engine; a 72-b.h.p. Leyland Diesel engine powers the two intermediate machines, and the largest compressor is available with a 180 b.h.p. six-cylinder Diesel engine either by Rolls-Royce or by Dorman.

COMPRESSED-AIR EQUIPMENT

The Norgren range of compressed-air equipment is being shown on the stand of Shipston Engineering Co., Ltd., Shipston-on-Stour, Warwickshire. This includes filters, regulators and lubricators. New is the MicroFog lubricator shown in Fig. 38 for injecting oil into lines supplying air tools or cylinders. There are two models for different pipe sizes; both have a transparent bowl with a capacity of $\frac{1}{4}$ pint, and will operate at pressures up to 150 lb. per sq. in. and temperatures up to 120 deg. F. A variable vane Venturi allows the flow to be adjusted for air flows in the range of 4 to 25 cub. ft. per min. It is claimed that the oil particle size is not larger than 2 microns, and that this allows even distribution throughout the air stream. Straight-through connections ease the problem of installation.

Also new is the pilot-controlled air-pressure regulator shown in Fig. 39. The use of a pilot allows the main regulator to be fixed in any convenient position while only the pilot need be fixed on the control panel. Continuous control can be exercised from 2 lb. per sq. in. up to 120 lb. per sq. in. The main regulator can accommodate flows up to 200 cub. ft. per min. and above.

PNEUMATIC EQUIPMENT

Pneumatic tools, compressors and dust extraction plant is being exhibited on the stand

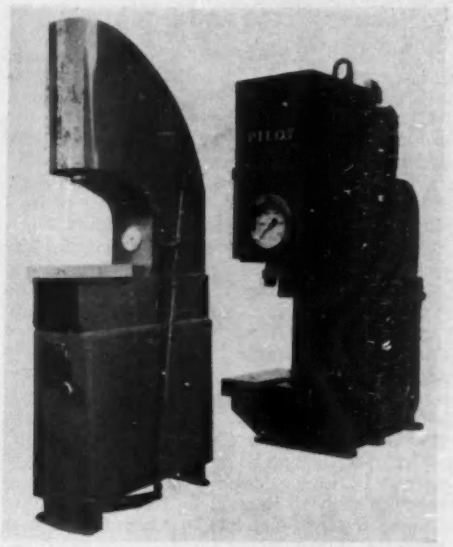

Fig. 36 Two new presses are among the hydraulic equipment on show. They are of 12 tons and 3 tons capacity respectively. Pilot Works Ltd.

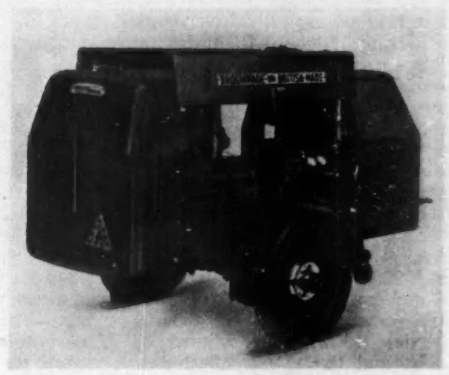

Fig. 37 120 cub. ft. per minute portable Diesel-driven rotary compressor. Broom and Wade Limited.

Fig. 38 MicroFog lubricator for compressed air lines. Shipston Engineering Co., Ltd.

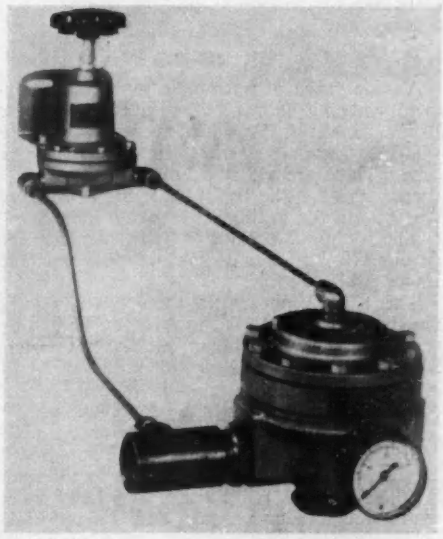

Fig. 39 Pilot-controlled regulator for air supplies. Shipston Engineering Co., Ltd.

Continuing Plant and Equipment

of Holman Brothers Limited, Camborne, Cornwall.

The Destructor equipment is designed for low-volume high-velocity systems of dust control, and was demonstrated for the first time at the 1955 Exhibition. Compressors shown include both the largest and the smallest in the range of two-stage machines, as well as portable units which can be fitted directly on to tractors. The smallest of the stationary compressors is the ATH8S single-cylinder air-cooled machine. As exhibited, it is direct-coupled to a 960 r.p.m. electric motor, and has a free air delivery of 65 cub. ft. per minute, against a pressure of 100 lb. per sq. in. The whole unit is mounted on steel skids. The largest is the T60R, which has a free air delivery of 535 cub. ft. per minute, also against a pressure of 100 lb. per sq. in., when operating at its maximum speed of 120 r.p.m. It is a double-cylinder water-cooled machine with an integral heat exchanger. The cooling water is circulated by a pump through the jackets and a radiator, and the unit can therefore be properly classed as a closed-circuit package unit.

POWER VANE COMPRESSORS

The Power Vane oil-flooded rotary compressors made by the Consolidated Pneumatic Tool Company Limited, include stationary variants as well as the portable range, and the compressor actually on view on the company's stand is an electrically-driven stationary machine delivering 120 cub. ft. of free air a minute at 100 lb. per sq. in. working pressure. This machine is supplying air for all Consolidated's pneumatic tool demonstrations. The compressor shown in Fig. 40 is similar in layout but of larger capacity.

Among portable compressors, five capacities are available: 120, 175, 210, 365 and 600 cub. ft. per minute, all operating normally at 100 lb. per sq. in. The two largest members of the family are powered respectively by 145 b.h.p. and 99 b.h.p. (continuous rating) Rolls-Royce Diesel power packs; the smaller compressors are powered by Perkins Diesel engines—the Model 210 by a six-cylinder 67 b.h.p. power pack and the two smallest compressors by a four-cylinder 53 b.h.p. power pack.

The Power Vane is a direct-coupled two-stage sliding-vane rotary compressor driven at engine speed through a friction coupling, which allows full advantage to be taken of direct drive but protects the compressor and engine shafts by automatically absorbing shock. Oil is pumped directly to the rotor roller bearings, and is injected into the rotor casings to serve simu taneously as lubricant, cooling medium and pressure seal.

AIR TOOLS

A wide range of pneumatic tools and equipment is being shown by Atlas Copco (Great Britain Limited, Beresford-avenue, Wembley, Middlesex, including three shown for the first time. These are a 5 cwt. hoist, a shear, and a corner drill. The hoist has been designed particularly for maintenance work in a ship's engine room. It can lift at 34 ft. per min. and develops full torque for any throttle position. Its weight is 40 lb.

The LBK31 pneumatic shear has a cutting speed of 20 ft. per min. in 14 s.w.g. mild steel sheet—the heaviest it can handle. It weighs 5¾ lb. and has a minimum bit radius of 1½ in. A built-in lubricator supplies the vane motor with oil and a silencer is built into the body.

For access to places impossible for a straight drill, the two models of the LBV32 corner drill have the chuck set at right angles to the main body. Model H11 has a speed of 1,100 r.p.m. with a single reduction gear, and is able to take drills up to ⅜ in. in diameter, while model H5 has a double reduction gear for a speed of 550 r.p.m. with a corresponding increase in capacity to ½ in. diameter. Both machines are driven by a vane-type motor and have built-in lubrication.

Inspection and Protection

TRANSPORTABLE X-RAY UNIT

A new transportable industrial X-ray apparatus, type TF1593, produced by Marconi Instruments Limited, St. Albans, Hertfordshire, is being exhibited on the stand of the English Electric Company.

The equipment has been dust-proofed and spray-proofed and is suitable for field, workshop, or laboratory installations. It comprises two units connected during operation by a low-tension cable. One of the units is the H.T. transformer/tube unit, which has been designed for 360 deg. circumferential techniques. It can be placed inside vessels, pipes, etc., to provide a single radiograph of an entire circumferential weld. Alternatively the unit can be used to radiograph, in a single exposure, a number of objects arranged in a circle. Normal 40 deg. cone beam techniques are also available. The unit contains two H.T. transformers, the tube filament transformer, the X-ray insert tube, and insulating oil. The rating of the equipment is 5 mA at 175 kV for continuous operation, or up to 8 mA for fifteen minutes with alternate fifteen-minute cooling intervals.

The control unit is housed in a separate steel box, shown in Fig. 41, and a second box is used to carry accessories such as a cooler, illuminating beam director, and inspection lamp. A feature of the control panel is that the controls are mounted and grouped in logical sequence. A summary of the operating procedure is engraved on the front panel. The controls include coarse and fine mains adjustment which cover the range 100-450 volts. The manufacturers claim that the equipment can be set up within ten minutes of arrival on site.

ULTRASONIC ANTI-FOULING

Among the exhibits on the stand of Marconi International Marine Communication Company, Limited, Marconi House, Chelmsford, Essex, is the "Protector" ultrasonic anti-fouling equipment. The Marconi-Postans system is used (as described in ENGINEERING, vol. 180, page 416, 1955) whereby continuous ultrasonic vibrations of the ship's hull discourage the adhesion of barnacles and other animal growth. "Grass" and weed formation is also reduced.

The complete equipment consists of a transmitter unit for generating the ultrasonic pulses, one or more transducers —each of which is mounted in a housing welded to the ship's hull—and two motor alternators with the necessary control and change-over equipment to provide alternative sources of supply, for continuous operation. An alarm device can be fitted to give indication of failure of the equipment. A typical layout is shown in Fig. 42.

The main controls of the transmitter unit are mounted on panels attached to the two upper units of its cabinet. The equipment has received the approval of Lloyd's Register of Shipping and conforms to the standards set by the normal G.P.O. requirements for climatic and durability testing. The power consumption is 1·5 kW.

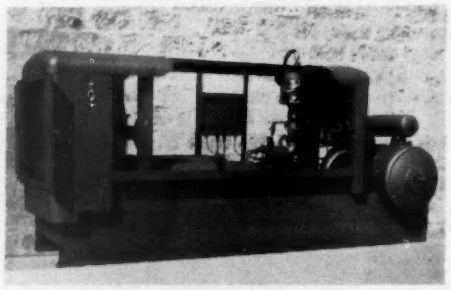

Fig. 40 Electrically-driven Power Vane rotary compressor. Consolidated Pneumatic Tool Co., Ltd.

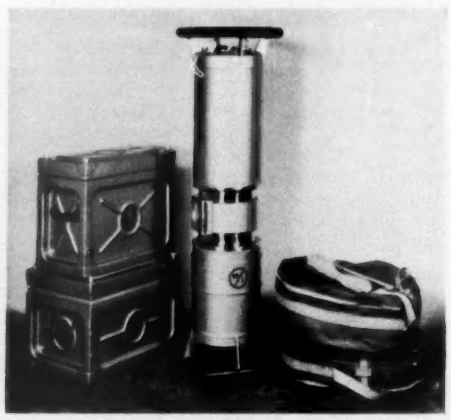

Fig. 41 The new Marconi transportable X-ray equipment is designed for 360 deg. circumferential techniques.

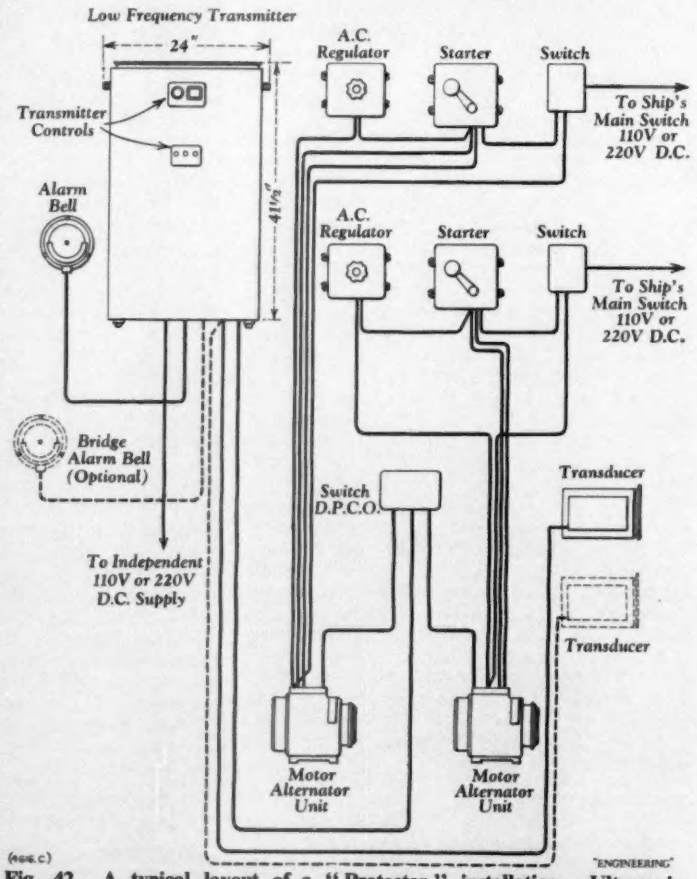

Fig. 42 A typical layout of a "Protector" installation. Ultrasonic vibrations applied to the hull plates by the transducer discourage barnacles. Marconi International Marine Communication Co., Ltd.

Management

Weekly Survey

A Tale of Two Aircraft

Within the last few weeks, the aircraft industry has provided two illustrations of the importance of two different aspects of management. According to the text-books, good management can be analysed under a number of headings which set out certain general principles. Two of these principles concern organisation on the one hand and intuition on the other. Many concerns have reduced their potential by failing to have these two ingredients in the correct proportion.

An interview given to *The Times* by Sir Robert McLean, formerly managing director of Vickers (Aviation) Limited, on his company's decision before the war to build a fighter aircraft with only the broadest directives and supervision over the design department illustrates a case in point. Controversy may continue to rage as to how far the Air Ministry at that time did in fact have a say in the design, but the principle involved is not significantly impaired by the detailed rights and wrongs of the Ministry's position. In this instance a decision was taken by top management to proceed with complete independence and at considerable financial risk. History has shown that the decision was probably the right one, but it might very easily have been wrong. In this instance the decision to back the judgment of a department against heavy odds and official preferences was an intuitive decision based on rare judgment. It is not always so.

The recent trouble over the decision to switch orders for the Bristol Britannia from B.O.A.C. to an American company is a reminder of the need to educate organised labour to understand management problems. The fact that pools of skilled or semi-skilled labour arise in the organisation of a flow of components in a complicated assembly programme is a symptom of production control difficulties. In any particular case these can arise owing to inefficient management or, if they are temporary, owing to the sheer complexities of the control problem. To suggest that the remedy to such a situation is large-scale expansion is to ignore the problem completely and to take a big risk that it will be exacerbated. To call for sweeping expansion of production lines in other factories as quickly as possible in order to meet both the American and British orders—with a passing swipe at the Bristol Aeroplane Company Limited—is to prescribe a sweeping cure without a thorough study of the facts.

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Going Back to School

Since the war, managements of American companies have been learning the value of the well-educated executive to the organisation. A never-ending education, carrying on after the business man has left school or university, is becoming more and more a part of the company executive's business life. The American Management Association estimate that 80,000 executives will take their courses and attend their seminars this year. The National Industrial Conference Board state that some 2,000 managers attend courses of two or more weeks in 32 universities. The General Electric Company run their own school at Crotonville, N.Y., with 350 places for high-level managers.

The largest private employer of civilian labour in the world, American Telephone and Telegraph Company, who employ nearly 800,000 people in the Bell System (100,000 are "managers") have recently published their revised training programme for management. In a most comprehensive review of the A.T. and T. system, *Business Week* (issue of August 10), indicates that courses are divided among three levels: supervisors and foremen, divisional and district managers, and general managers. Each group receives training under the same three broad headings—techniques and skills, economics, personnel-labour relations and the humanities—but individual courses within each are tailored to meet the requirements of the three levels. In some cases, however, when all levels can be expected to deal with similar situations, they are taught the same things, as, for example, "how to run a conference." Under the same heading of techniques and skills are included "the importance of listening to people," "planning and controlling the job," and various headings for communications. There is considerable emphasis on human relation problems, explaining company policy, the meaning of contracts with organised labour, and generally on job definition and training methods. The fact that senior management is subjected to a ten-month course on the humanities shows the tremendous importance American industry now attach to a good cultural background.

The philosophy behind A.T. and T.'s programme is to give "likely candidates a chance to develop their own well-rounded abilities—and the broader their education the better." The company reject the idea that a manager needs only to know business methods.

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Conflicting Loyalties

The problem of getting able men into Government service in the United States recently caused President Eisenhower to say with some feeling that it was high time Congress altered the penal severity of their "conflict-of-interest" law: "It reaches into such details of a man's life and business," he said, "that if you want to get a younger effective executive from business to do one of the jobs here, you are practically ruining his business career and future."

Congress committees are tough on the promising man for whom public service is preferable to industry. In this country it goes much further than that: the difficulty of getting top men into Government applies equally to the filling of high posts in the nationalised industries. Perhaps even more so, for while a politician may have to go through a series of vigorous tests, resign directorships and sell large shareholdings "likely to affect his objectivity" the chairman of a nationalised board will also be subjected to constant sniping from the floor of both Houses, echoed throughout the Press, to any witch-hunt of the day likely to have popular appeal, and to the whims and particular viewpoint of the Minister concerned.

In the old days—and even now in most of the world's countries—getting public office meant a fortune earned in a short time. For British public men it means relatively small earnings, practically no perks and, for members of public boards, tied hands. The importance of this to the country should not be underrated. There is no surer way to getting mediocrity in positions of vital influence in the conduct of affairs. It would be a thousand pities if the successful industrialist, or the promising young man, no longer felt attracted by public responsibilities.

In the United States the appeal of the glitter and eminence of public service is still high. It was enough to get Charles E. Wilson, former president of General Motors, to join the Eisenhower administration. But the penalties are great. The Secretary of the Treasury must not own Government bonds or shipping shares because he makes policy in the fields of finance and customs procedure. The new Minister of Defence, Neil H. McElroy, may have to sell all his shares of Proctor and Gamble, whose president he was, and to resign his directorships of the General Electric Company and Chrysler Corporation. United States committees, however, can be benevolent watchdogs: as a member of the Senate recently explained "We are interested in appearances. We try to avoid any situation that looks shady, or where there might be an opportunity for criticism later." But President Eisenhower's problem remains and grows in importance, as in this and other countries, in step with the growth of Government controls and influence.

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New Pattern for Employment

With the backing of an impressive set of figures the Ministry of Labour claim success for their labour re-deployment campaign. An example is given of a motor firm who declared 1,325 and then a further 1,300 men redundant, giving each man three weeks' notice. Most of the workers had had offers of employment long before their notice expired. There is no doubt that the wave of redundancy which followed the recession in car demand put the Ministry on their mettle. Employment exchange staffs did a good and quick job, interviewing during both the day and night shifts. At the same time it should be borne in mind that there was a serious labour shortage throughout the country, particularly in engineering.

The annual report of the Ministry of Labour for last year (Cmnd. 242, H.M.S.O., 6*s*.) indicates changes in the pattern of demand for labour which have checked the post-war trend towards a falling level of employment in the basic industries and a rising level in manufacturing. It is, however, much too early to conclude that the shortage of labour in the engineering and metal industries is over. The fall of 6,000 in the numbers employed in foundries suggests that the squeeze may have been too much for the small firm but there is obviously a considerable shortage, particularly of skilled operatives, in most sections of engineering.

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How Scarce Will Labour Be?

The latest issue of the Treasury's *Bulletin for Industry* draws attention to the fact that industrial productivity has increased over the first six months of this year. It is estimated that, in June, the index of production was back to its peak level achieved at the close of 1955 and was 3 per cent. above the level of December, 1956. Employment has been rising, though more slowly. According to the *Bulletin*, unemployment has been declining rather more rapidly than would be expected from a seasonal trend alone. It is significant, too, that there has been change in the rate of expansion as between capital goods and consumer goods. Whereas in 1956 the boom in capital goods was sustained, the recent buoyancy of industrial production has owed much to consumer durable and non-durable goods.

One of the few successes of the credit squeeze has been a modest switch of labour from consumer to capital goods. The movement of labour was by no means completely satisfactory, for some foodstuffs firms attracted labour from consumer durable goods industries such as motor cars. It was possible to say, however, that some of the labour which was squeezed from certain industries found its way into engineering and metal-working concerns. Even this modest gain could be lost, however, if the consumer goods boom of 1957 coincided with a drop in building activity and reduced orders for plant and equipment. It is possible, although the statistical evidence is still slender, that a renewal of over-full employment might coincide with a switch in labour to an increasing extent into certain consumer goods industries. If this should happen, any gain for the export industries from the credit squeeze will be seriously modified.

Marketing

ENGINEERING FIRMS IN THE FREE TRADE AREA

8—F. L. SMIDTH AND CO. A/S.

Cement has been one of the most prosperous industries since the war. A long-term trend in favour of the use of reinforced concrete has coincided over the last decade with large rehousing programmes and the need to carry out a great deal of rebuilding due to war damage. In most European countries there has been a notable expansion in production since the war years and in the case of the United Kingdom, Germany, and France that expansion is still going on, nor is it likely that the increase will exhaust itself for a number of years to come. The rate of increase of production over the last eight years can be judged from the figures given in Table I.

Probably the best known name in cement making machinery is F. L. Smidth and Company A/S of Denmark. This company was founded in 1882 and to-day it has cement machinery factories in Lübeck in Germany and near New York in the United States as well as the parent factory near Copenhagen. It has been estimated that over the last 30 years F. L. Smidth have built about 40 per cent. of the world's cement-making capacity, and over that period the number of its workers and technical staff has increased from under 300 to about 1,100.

The F. L. Smidth organisation thinks of itself basically as a cement machinery manufacturing concern with certain interests in other outlets for grinding, crushing and kiln machinery. Over the years, however, circumstances have forced the organisation into providing a world-wide consultancy service in cement and the actual ownership of cement works. The result is that to-day the F. L. Smidth ramifications are exceedingly wide.

The circumstances which forced the company to broaden their interests outside machinery building centred on the rather spasmodic demands that occurred at one time for new cement machinery. New cement works were not put up as regularly as they are at the present time and there was a chronic shortage of experienced engineers with specialised knowledge of cement machinery and its installation. Large engineering concerns such as Vickers in this country and, say, Allis-Chalmers in the United States did not find it worth their while to build up a core of experienced cement machinery engineers. F. L. Smidth conceived the idea of establishing a world-wide organisation which would be able to work on a sound economic basis owing to its wide geographical coverage. In consequence, the company developed as consulting engineers.

COMPANY HOLDINGS

In due course, in order to ensure that it was fully up to date on technical matters and to give it the entrée to local cement industries, the organisation acquired holdings in cement works. To-day, it has offices throughout the world, very often operating as subsidiary companies. Through a subsidiary called Cement Investments Limited it holds shares in cement companies throughout the world. The precise extent of these holdings probably fluctuates. For example, F. L. Smidth are known to have had a controlling interest at one time in the Tunnel Portland Cement Company, Limited, in this country, which in turn controls the Ribblesdale Cement Company, Ketton Cement Limited (in Eire), the National Portland Cement Company, Inc., in the United States and the Caribbean Cement Company, Limited, in the West Indies. The connection with Tunnel is thought to have been for some years only a consultancy relationship but the ramifications which can be developed from one key holding are illustrated from this United Kingdom example. There are, or have until recently been, similar holdings through Kursachen Cement Company in Germany (this connection being in East Germany will be in abeyance), The Burma Cement Company in Burma, Société de Ciment Portland de Helwan in Egypt, S.A. des Ciments Turque d'Anatolie in Turkey, East African Portland Cement Company, Limited, in East Africa and the Secie Cement Company in Portugal.

Holdings such as these also give the Smidth organisation the standing of a local company in the countries concerned, which is bound to aid business. Nevertheless as a technique of development it must have its limitations. Granted even the most astute financial arrangements, the acquisition of cement works involves tying up considerable sums of capital, and in the more highly industrialised areas Smidths are up against combines, investment organisations and large producing companies which are also interested in acquiring new or existing cement works. Examples of these are the Holderbank Financiere Glarus A.G. which controls a large portion of the Swiss cement industry, and has large interests in Belgium, South Africa, Canada, Australia, Greece and Holland. In the United Kingdom, the Associated Portland Cement Manufacturers Limited control several other companies in this country and have interests in Canada, South Africa, Australia, New Zealand and Malaya as well as a number of other unpublished holdings. It is indeed the common form of organisation throughout the world for cement works to belong to companies which are in turn members of large national or international groups.

Although F. L. Smidth are machinery makers they have pursued a flexible policy so far as sub-contracting is concerned. In this country, for example, they have a fairly long-standing arrangement with the David Brown Industries Limited for the supply of " symetro " gears for cement machinery supplied in this country and even abroad. On the other hand, they are known to have pulled out of India some years ago because local interests wished to make certain cement machinery instead of buying it from Smidths although, they wished Smidths to carry on in an advisory capacity.

COMPETITION

Although Smidths are outstanding in cement machinery there are other powerful concerns whose challenge may well be growing. Exports of cement making machinery are not available for all countries but Table II gives some impression of the trend of exports in categories of machinery in which cement-making equipment is at least an important constituent.

TABLE I.—*Production of Cement in O.E.E.C. Countries*
Million metric tons

	United Kingdom	Western Germany	France	Belgium	Holland	Italy	Portugal	Norway	Sweden	Denmark
1948 ..	8·7	5·6	5·8	3·4	0·6	3·1	0·5	0·5	1·5	0·8
1956 ..	13·0	20·1	11·4	4·7	1·3	10·7	0·9	0·7	2·5	1·2

TABLE II.—*Exports of Cement-Making and Allied Machinery*
£000.

	1954	1955	1956
Denmark	7,030	7,810	—
Germany	—	15,700	20,200
Belgium	1,270	1,420	1,580
France	1,010	1,410	—
United Kingdom ..	989	1,137	1,016

Exports of machinery (so far as can be ascertained without reasonably up-to-date figures) have been expanding, notably from Germany where Smidths have a factory. But even in the United Kingdom, the annual rate (based on six months' figures) has gone up to £1,340,000 in 1957.

Competition in the European market comes from several sources. At the time when E.C.A. dollars were available in larger quantities than they are now, the two large American cement machinery makers, Kennedy-Van Saun Manufacturing and Engineering Corporation, Inc., and the Allis-Chalmers Manufacturing Company, Inc., were able to obtain useful contracts, but their challenge has probably receded in the last year or two especially as their prices tend to be high.

The German challenge is a serious one. Polysius, MIAG, Krupp and Klöckner-Humboldt-Deutz have all reasserted their position in the cement machinery market since the war in varying degrees and have met with success in South America and in the Middle and Far East. Their prices have been keen and credit terms attractive. German equipment has also been purchased on a growing scale in western Europe.

In Belgium, one concern has tried to compete with Smidths both in cement manufacture and as a consultant in cement-making machinery. This company, Cimenteries et Briqueteries Reunies S.A., which was established originally as a cement-making concern, has had some success (as might be expected) in the Belgian Congo as a consultant on installing new capacity, but is not thought to have offered very serious competition elsewhere.

In this country the main suppliers of cement-making machinery are Vickers-Armstrongs Limited, Ernest Newall and Company, Limited, and Edgar Allen and Company, Limited. The biggest British challenge comes from Vickers-Armstrongs who are thought to have some sort of working arrangement with Cie de Fives-Lille pour Constructions Mechanique et Entreprises in France and to have been developing their interests in cement machinery making in the Dominions.

DUTIES AND PRICES

By reason of its wide international ramifications, the F. L. Smidth organisation is clearly in a very strong position under the Free Trade Area. It is represented by some sort of organisation in all potential member-countries of the F.T.A., and can in most cases operate as a local company. That does not mean to say, however, that the Free Trade Area will have no influence on that company's sales or on its sub-contracting policy. Because of war damage and likely industrial expansion under the Free Trade Area requiring increased factory space, the outlook for cement is particularly bright in Germany and it may be that capacity will increase more rapidly there than in other countries in western Europe. That being so, the challenge of German cement machinery companies is hardly likely to be reduced. Since Smidths already have a subsidiary factory in Lübeck, they may be well placed to take advantage of any particularly pronounced German expansion. On the other hand, specialisation within the Free Trade Area might increase the attractiveness for Smidths to make more machinery in Denmark which would result in less sub-contracting for local companies and possibly even the concentration of the German factory on special kinds of machinery only.

It is not likely that the Free Trade Area will

affect the international trade in cement very much. At the present time, cement has been liberalised by Sweden, Switzerland, Portugal, Italy, Germany and Austria. In the case of the United Kingdom, there is still control of imports from the dollar area and eastern Europe. A mild form of licensing exists in the case of the Netherlands and Belgium and Luxembourg. Only France, Denmark, Ireland, Norway and Turkey have not liberalised their cement import trade. At the present time only France and Italy have a fairly high tariff against cement. Comparative rates of duty are set out in Table III.

TABLE III.—*Import Duties on Cement in O.E.E.C. Countries, January*, 1955

Country	Rate of duty
Benelux	3 per cent. *ad valorem*
Denmark	Free
France ..	10 per cent. *ad valorem*
Greece ..	2 to 3 metallic drachmas per 100 kg.
Italy	General 25 per cent. Applied rate in fact 16 per cent. *ad valorem*
Norway ..	0·80 kr. per 100 kg.
Portugal	0·01 to 0·90 esc. per kg.
Sweden ..	0·60 kr. per 100 kg. gross weight
Switzerland	2·00 S. fr. per 100 kg.
Turkey ..	5·13 £T. per gross ton
United Kingdom	5 per cent. *ad valorem*

The suspension of duty will thus mean a difference of between 3 and 5 per cent. in the price of cement across most national frontiers, not a penal level to dismantle nor one which is likely to have seriously impeded the international trade in cement. In Table IV prices ex-works are compared in different countries for standard quality Portland cement, without packing.

These prices are now somewhat out of date, but they show not only that the local tariff structure has probably not influenced the flow of cement but also that United Kingdom cement is one of the cheapest in western Europe. On the basis of 1953 prices, only Belgium and Denmark can claim a lower ex-works price. At the present time the ex-works price of United Kingdom cement is considerably below that in Germany and France. A London price of £5 12*s.* per ton compares with £6 6*s.* in Frankfurt and £8 6*s.* in Paris. Differences of this size before the Free Trade Area comes into existence suggest that transport charges play a large part in the international cement market, as they do even in the local United Kingdom market.

TABLE IV.—*Price Trends of Cement per Ton*
In United States dols.

Countries	Qualities	1950	1951	1952	1953	1954	1955
Belgium	—	9·58	10·00	10·24	10·18	10·18	10·18
Luxembourg ..	—			Between 11·00 and 12·00			
Denmark	—	8·24	10·48	10·86	10·12	8·86	9·67
France	Portland 250/315	8·91	10·88	12·64	12·48	12·26	12·37
Italy	Portland type 500	12·24	12·24	12·88	12·88	12·88	12·88
Norway	—	9·46	9·46 11·04 11·32	–11·32 –12·16	–12·16	12·16 11·60	–12·15
Netherlands	—	9·50	10·80	11·00 (13·88)	11·30	11·60	—
Portugal	—						
Sweden	—	11·50	13·83	15·07	14·09	13·52	13·52
Switzerland	Basle price .. .. .. (discounts deducted)	12·56	12·70	13·14	13·23	13·23	13·23
United Kingdom ..	—	—	—	10·90	11·10	—	—

Information on the transport costs of cement in the United Kingdom is scanty but it is probably of the order of 2*d.* to 3*d.* a ton-mile which suggests that it might stand some hope in the F.T.A. of entering on a larger scale into western France (say, up to 100 miles from the Thames Estuary). Beyond that, transport costs forbid a larger trade except where local capacity is insufficient to meet demand. Under such conditions it is not easy to foresee any notable increase in the intra-European trade in cement except in the immediate vicinity of frontiers. It seems more likely that there will be a continuing expansion in demand which will be supplied from local works.

MARKET REDISTRIBUTION

It seems likely, too, that the Free Trade Area may cause a modest redistribution in the cement market. Those parts of France and Italy which are fairly close to cheap foreign cement works may take their supplies from these sources across the frontier. The countries likely to benefit are Germany, Belgium and the United Kingdom, but how great the benefit will be it is difficult to say. French and Italian cement manufacturers might be prepared to suffer substantial cuts in gross profit margins in order to compete with imported cement and it is likely that they can endure some price fall without seriously impairing their capital assets; a few of the more efficient might even be able to fight back by exporting into home markets hitherto protected by zoned or fixed prices. This is a possibility which cannot be completely ignored in the United Kingdom domestic market. Whatever may happen, the marginal redistribution of the cement market is likely to have only a modest effect on the long-term trend of cement capacity in western Europe. Such as the impact on capacity may be, it is likely to be favourable to cement machinery makers and their sub-contractors in Germany, Denmark and the United Kingdom—in that order of priority. F. L. Smidth and the German cement machinery makers are very well established in the German market and Smidths in particular have a big interest in the United Kingdom cement machinery industry as a competitor in the field with British companies.

It seems probable that the Free Trade Area will bring an increasing awareness of the possibility of importing high quality cement machinery from other countries, and if this leads to a greater awareness by cement manufacturers of alternative sources of supply they may even approach other concerns in the United Kingdom to make cement machinery, concerns which up to the present may not have been interested in this line of business. The United Kingdom rights of one of the largest United States cement machinery manufacturers are held by a well-known English engineering company which has never taken advantage of them. The British Thomson-Houston Company, Limited, started making some cement machinery a few years ago in response to a demand for higher performance equipment than was obtainable from usual suppliers. This kind of development may go on under the Free Trade Area on an increasing scale. Superficially, therefore, the Free Trade Area may not have a big influence on cement machinery makers in this country for some time, but it may generate a technical ferment which may have consequences which cannot yet be foreseen.

Research and Development

DEVELOPMENTS IN CRANKCASE OIL-MIST DETECTOR

SAFEGUARD AGAINST EXPLOSION HAZARD

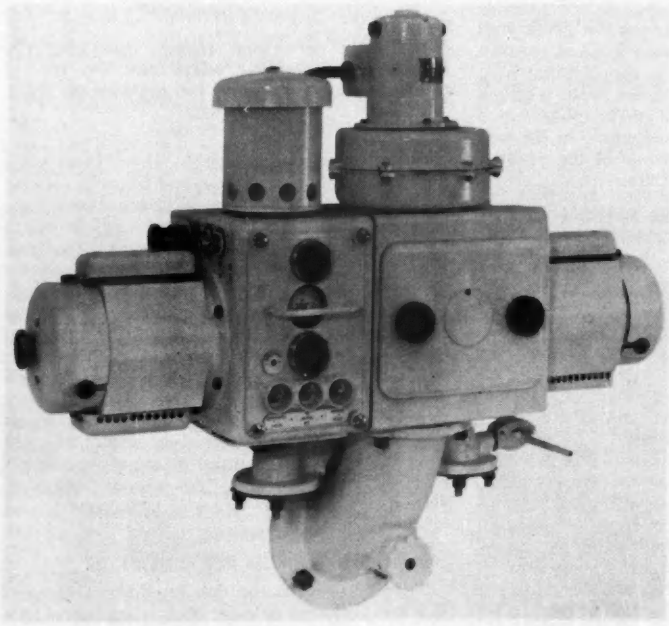

Fig. 1 The revised version of the Graviner-B.S.R.A. photo-electric oil-mist detector unit is now installed externally to the crankcase. The equipment provides remote continuous indication or chart recording of the oil-mist density as well as actuating alarm signals.

For the past few years, Diesel engine users—and particularly marine engineers—have been seriously concerned with the hazard of crankcase explosions, and much research has been going on into the causes of such explosions* and into remedial measures,† such as the detection of overheating, and the provision of relief vents and flame traps to limit the explosion pressure and spread of combustion. While the provision of internal oil-wetted relief-valve flame traps and partition flame traps appear to offer great promise in ameliorating destruction and danger when an explosion does occur, it would clearly be preferable to avoid the explosion altogether. For this purpose a reliable detector of incipient

* J. H. Burgoyne and D. M. Newitt (Imperial College), "Crankcase Explosions in Marine Engines." *Trans. Inst. Marine Engineers*, Vol. 47, No. 8, August (1955).

† H. G. Freeston, J. D. Roberts and A. Thomas (Thornton Research Centre), "Crankcase Explosions: An Investigation into some Factors Governing the Selection of Protective Devices"; W. P. Mansfield (British Internal Combustion Engine Research Association), "Crankcase Explosions: Development of New Protective Devices"; and discussion. *Proc. I.Mech.E.*, Vol. 170, No. 24 (1956).

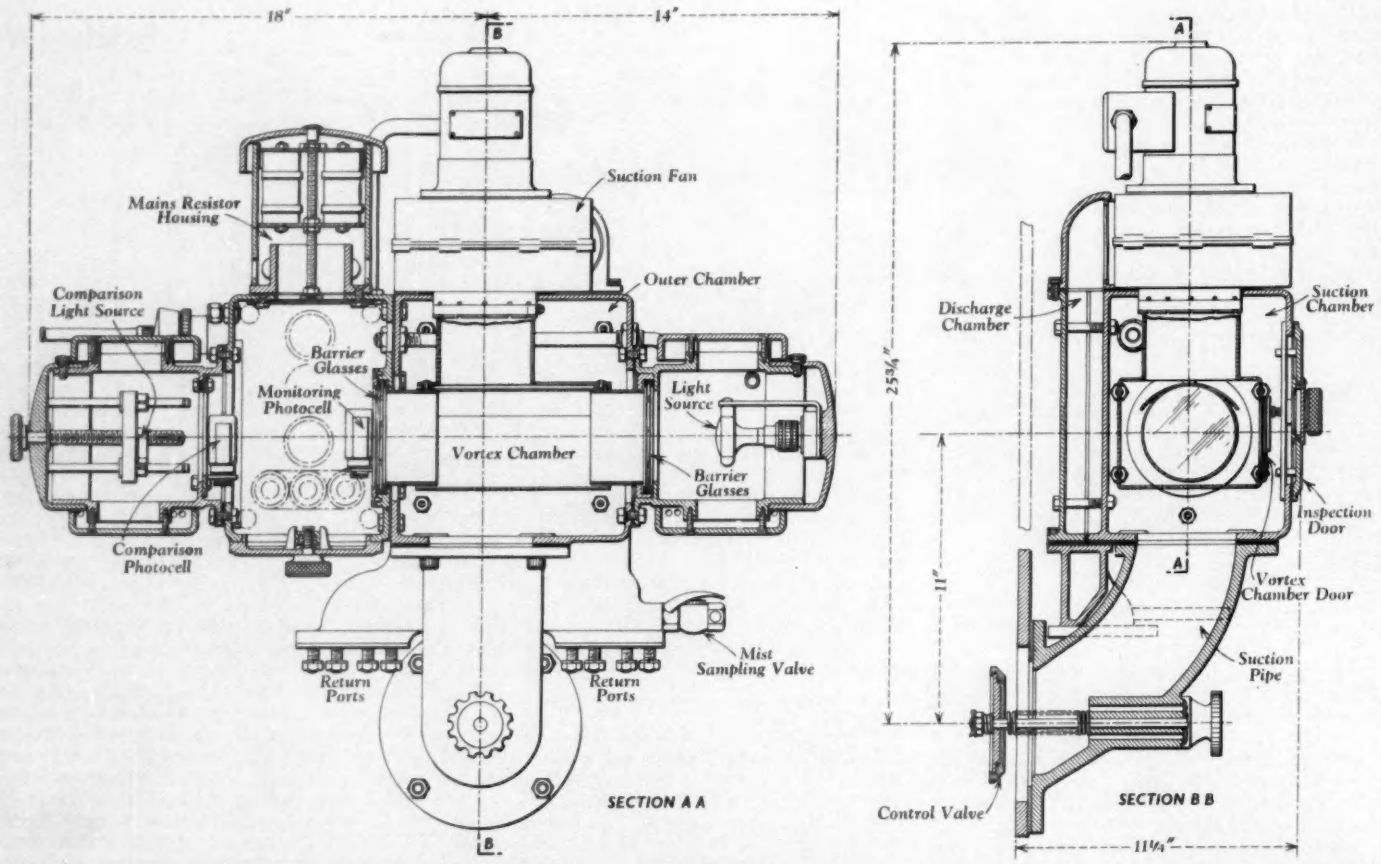

Fig. 2 Sectioned views of the oil-mist detector. Oil mist from the crankcase is continuously circulated through a monitoring chamber; the output from the monitoring photocell is balanced against that from a reference cell.

potentially-explosive conditions is required, and it is this approach to the problem that has been sponsored by the British Shipbuilding Research Association.

PROTOTYPE DETECTOR ON TRIAL

The Imperial College researchers concluded that the most potent cause of Diesel crankcase explosions was the formation of a dangerous concentration of oil mist, caused usually by hot spots in the crankcase. Examples of such hot spots would be overheated pistons or bearings or overheated areas of the crankcase wall arising from scavenge-duct fires. They also suggested that such oil-mist concentrations could be detected by optical means. As a result, the B.S.R.A.-Graviner photo-electric oil-mist detector was developed by the Graviner Manufacturing Company, Limited, Gosport, Hampshire, and a description of the prototype instrument was given in an article in the June 17, 1955, issue of ENGINEERING. At that time, service trials of the instrument, installed on five ships of different lines, had only just commenced. As is often the case, service experience brought to light unsuspected problems and in consequence the Graviner company have completely redesigned the oil-mist detector. The revised version is now undergoing extensive proving at sea on a variety of large Diesel engines, arranged by the British Shipbuilding Research Association. The unit is being demonstrated in action at the Engineering, Marine, Welding and Nuclear Energy Exhibition at Olympia on the stand of D.S.I.R.

SELENIUM PHOTOCELLS INADEQUATE

Before describing the current Graviner-B.S.R.A. oil-mist detector, it is interesting to recall briefly the characteristics of the prototype detector and to see how the new instrument departs from the original conception. In the original instrument, a photo-electric probe was inserted into the crankcase, the probe comprising a chamber with a light source at one end and a photocell at the other. Any oil mist present in the crankcase was able to enter the probe body through louvres, and above a given oil-mist concentration, the attenuation of the light falling on the photocell caused a relay to actuate audible and visual warning signals. For simplicity, a selenium photocell, which energised the relay directly without amplification, was selected. However, although attractively simple in theory, in practice under sea-going conditions it was found that the selenium cells were unable to stand up to the high operating temperatures and to moisture, and their stability decreased progressively. In the new instrument, precision-made caesium cells are employed, and this has necessitated the introduction of an amplifier.

The probe, too, has been abandoned for several reasons: on many engines considerable difficulty was found in installing the probe in a suitable position in the crankcase—and such an installation was not generally very popular with marine engineers. In service, the probe required constant servicing as a result of the oil-saturated and high-temperature environment. In the new instrument, therefore, the whole of the installation is external to the crankcase.

REMOTE RECORDER WARNS OF TROUBLE COMING

An advantage of the developed oil-mist detector is that it can provide, in addition to the warning signals, a remote continuous indication of oil-mist concentration in the crankcase, either on an indicator or a chart recorder, whereas the original detector was designed only to trigger off the warning system when the concentration had risen to a value of five per cent. of the lower limit of explosive concentration.

When a chart recorder is fitted, it is provided with a graduated scale divided into green, amber, and red sections. So long as the trace remains within the green sector, the engine-room staff can be confident that all is well within the crankcase, but should the trace begin to creep upward into the amber zone, then they are alerted to the fact that something is getting hot within, and it is then possible for them to slow down and, possibly, to stop the engine and to seek out and remedy the defect. The Graviner company, however, point out that there may be some danger in stopping an engine, once oil mist has been generated by hot bearings, unless carbon-dioxide is first injected to inert the crankcase atmosphere. The reason is that, although a bearing may have run hot without causing an explosion or fire, it can happen that an explosion may occur after the engine has stopped: in such cases, initially, the oil-mist/air mixture is over-rich for spontaneous ignition, but as the engine cools the mixture ratio changes and ultimately passes through the temperature range favourable to spontaneous ignition. An inert-gas injection system is, then, an essential corollary to an oil-mist detector unit.

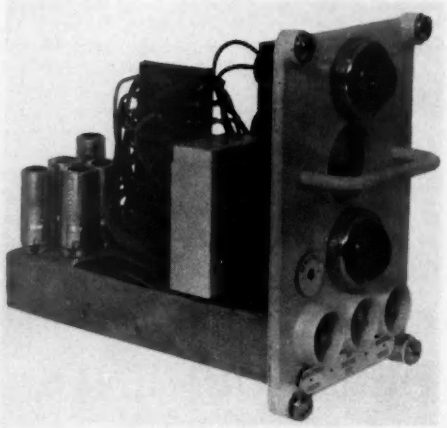

Fig. 3 The power-unit chassis containing the amplifier, the warning relays and the control panel, is readily removed for replacement by a spare unit.

BALANCED PHOTOCELLS

Turning now to the details of the Graviner-B.S.R.A. oil-mist detector that is now available

Continuing Research and Development

to the shipping world and to industry; it comprises a monitoring chamber bolted directly to the engine crankcase, through which the crankcase atmosphere is continuously circulated by a motor-driven suction fan. By keeping the suction ducting connecting the chamber with the crankcase short and of large diameter—4 in. —condensation is minimised and a sample truly representative of the mist-density condition within the crankcase is obtained. The monitoring chamber comprises, in fact, an outer chamber and an inner vortex chamber so arranged that the flow of gas is kept clear of the barrier glasses at either end of the chamber, thus minimising servicing requirements. These barrier glasses protect a light source at one end and a photo-electric cell at the other end, the photocell being housed actually in a power-unit compartment.

The output from the monitoring photocell, which depends upon the clarity of the gas passing through the chamber, is balanced against the output from a comparison photo-electric cell, the light source for which is housed in an isolated compartment bolted on to the other side of the power unit compartment. Should the output from the monitoring photocell fall below that of the comparison photocell as a result of increasing mist density, the resulting out-of-balance current is amplified in the power unit. The amplified current operates the continuous indicator or chart recorder and, when it reaches a value corresponding to an oil-mist concentration of 1·25 mg. of oil mist per litre of crankcase volume, i.e., 2½ per cent. of the lower explosive mixture, it actuates a relay setting off a warning gong, and extinguishes the normal green indicator light, illuminating a red warning light on the front of the power unit panel, and at the same time switching off the circulating fan. The instrument can readily be arranged to give automatic CO_2 flooding at the critical concentration, but generally ships' engineers prefer to retain control of the inhibiting system themselves; and indeed, if the chart records are interpreted intelligently, it should usually be possible to take remedial action well before the alarm conditions are reached.

MINIMUM SERVICING

The power unit control panel includes, in addition to the green and red indicator lamps, a main on-off switch, a warning reset push-button which enables the engineer to reset the instrument after the alarms have actuated, controls and a check-meter for adjusting the sensitivity of the instrument. The sensitivity can only be checked when the monitoring chamber is free from mist, and therefore a control valve is provided in the suction port to shut off the crankcase from, and to admit air to, the monitoring chamber.

Because electronic engineers are not normally part of the engine-room complement, every effort has been made to minimise inspection and servicing. Automatic warning of the failure of a lamp or of the valves is provided by the extinction of the green normal light and intermittent flashing of the red light (as opposed to the continuous danger warning) unaccompanied by any aural indication. In addition, at the special request of the Ministry of Transport and Civil Aviation, a mist-sampling valve has been provided to enable the engineer to check up, visually and by smell, whether in fact there is oil mist present in the crankcase. The entire power-unit chassis can be readily withdrawn from its housing, after removing four bolts, and replaced by a spare unit. The sensitivity check would normally be carried out about once every three months, or when the recorder chart showed abnormal indications; the monitoring chamber and barrier glasses, also, are unlikely to require cleaning more often than once in three months.

One Graviner-B.S.R.A. oil-mist detector will provide adequate coverage for engines with up to six cylinders—provided that the engine is unpartitioned. In the case of a large engine which is partitioned to give in effect two crankcase groups, it will, naturally, be necessary to provide two such units.

LABORATORY AND FIELD TESTS

As already mentioned, the new unit has been extensively tested, firstly on Graviner's own laboratory test rig, which comprises a boxed-in compartment with a glass front to which the oil-mist detector is secured in the same manner as it would be attached to an engine crankcase. Within the compartment is a motor-driven shaft running in a bronze bearing. The latter can be adjustably clamped on to the shaft to produce varying degrees of friction, and the shaft is fed with a continuous stream of lubricating oil spray. As the bearing overheats, oil vapour is generated and eventually condenses to form a visible mist of increasing density. The oil-mist detector, however, beats the human eye in detecting the first traces of mist and the chart trace begins to show an upward trend before any appreciable increase of density is apparent to the eye.

As a result of work done on this rig, the Graviner company have concluded that the probable sequence of events in a Diesel engine crankcase in which the bearings, or other parts, have become overheated, is as follows: firstly, oil mist is generated. If the bearings run dry during the early stages, ignition from red-hot metal particles or sparks may occur if a small pocket of oil mist is generated of sufficient concentration to be explosive. This is likely to produce a "puff" which may lift the relief doors or other safety devices. If, on the other hand, the crankcase is nearly filled with oil mist within the explosive limits, ignition may result in a violent explosion. Repeated experiments indicate that, in such conditions, the crankcase atmosphere will have the appearance of tightly-packed cotton wool through which the rays from a strong light will penetrate only a few inches. In the case of an engine fitted with an oil-mist detector, the alarm would be given long before such a condition was reached.

Following up the rig tests, oil-mist detectors are now undergoing service trials on an industrial Diesel engine on the engine manufacturers' development test-beds; and on five Diesel-driven ships which are operated by five British shipping companies.

LUBRICATION AND WEAR

I.Mech.E. Conference in October

Just 20 years have elapsed since the Institution of Mechanical Engineers organised the first international discussion of any size devoted to lubrication and lubricants, and the success which attended that conference may be measured, in part, by the steady demand which still exists for its *Proceedings*.

The Council of the Institution, considering that the time has arrived for a reappraisal of the subject, in the light of the advances which have taken place during this intervening period, have decided to hold a further conference on lubrication problems, and have chosen wear as an additional theme in view of the need for a systematic study of wear problems, such as an elucidation of how this phenomenon arises. A committee has accordingly been set up, under the chairmanship of Dr. D. Clayton, M.I.Mech.E., and arrangements have been made to hold the conference in London from October 1 to 3, next.

Sir George Nelson, Bt., LL.D., M.I.E.E., the President of the Institution, will open the conference and it is expected that about 104 papers will be presented at the ensuing technical sessions, which will be held at Church House, Westminster, except certain group meetings due to take place at the Institution building and at the Federation of British Industries in Tothill-street, S.W.1. The papers have been divided under the headings: hydrodynamic lubrication; boundary friction; boundary lubrication, including ball and roller bearings, gear lubrication and grease lubrication, bearing metals, novel bearing materials, glands and seals, and utilisation and special applications; and wear.

In view of the many authors concerned and the number of papers presented and to allow additional time for discussions, reviewers and reporters have been appointed to summarise the papers in each section, making reference to particular papers as considered significant. It is expected that advance copies of the papers will be available, either in complete sets or individually, as required. Bound volumes of *Proceedings*, containing the papers and discussions, will be obtainable at a later date.

Interest in the conference is widespread, as is shown by the fact that a considerable number of the papers are being contributed from overseas, including five from Russian sources and many from the United States. Arrangements are being made for the re-presentation of some or all of the papers at meetings under the sponsorship of the American Society of Mechanical Engineers in Toronto in October and in New York in December. Requests for papers, or to attend the conference or the overseas meetings should be addressed, respectively, to the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1; or to the American Society of Mechanical Engineers, 29 West 39th-street, New York, 18.

RESEARCH COUNCIL

The Advisory Council, D.S.I.R., has recently issued its last report. It is to be replaced by a Research Council with a rather different status: with the same responsibility to advise but with the freedom to make decisions and carry them out. The interim report of the Jephcott Committee recommended such a change, which should make it easier to ensure that the best use is made of scarce resources. Operating as a Government Department or agency, D.S.I.R. could not determine the scale or duration of research projects, or to assess priorities. "Much is started," the report states, "but not enough is stopped."

The main conclusions of the report is upon a familiar theme: Britain's scientific manpower is at present far from sufficient to meet all the needs of industrial research. The shortage of manpower, rather than the shortage of money, has tended to restrict the Department's activities. Total expenditure, at £7·6 million, was about £1 million more than the previous year. The major impact of the credit squeeze was on the building programme. Two new projects—an experimental road system designed as part of a new Road Research Laboratory at Crowthorne, Berks, and a new chemistry building at the Building Research Station—were postponed.

The research carried out during the year by the Department or its 46 allied associations is described in some detail. Nucleonics has played a major part in the programme, including an investigation of the large amounts of thorium-bearing minerals arising as by-products during the course of tin and columbite production in Nigeria. The development of control equipment for machine tools and research into the continuous casting of steel, are other features of a crowded year. Among new undertakings the administration of a new National Science Library (starting with a Russian Scientific and Technical Section) is one of the most interesting.

Book Reviews

EXPLAINING SCIENCE TO THE PUBLIC

The Science Museum: The First Hundred Years. *H.M. Stationery Office, York House, Kingsway, London, W.C.2.* (15*s.*)

A hundred years ago the South Kensington Museum was opened to the public. It contained numerous objects which had been shown at the Great Exhibition of 1851, together with collections illustrating foods, animal products, building materials and educational apparatus. From this miscellany, housed in corrugated-iron buildings known disrespectfully as "The Brompton Boilers" (not without justification, as contemporary illustrations show), the present Science Museum, with its unparalleled collection of technical and scientific exhibits, has grown.

In its early days, in fact for the first half-century of its existence, the Museum was devoted to art as well as science, but in 1909 the art side of the Museum's work was transferred to the new Victoria and Albert Museum. Soon after this the Bell Committee was set up to consider the question of housing the science collection suitably, and of developing it further. It is on the report of this committee that the Science Museum as we know it to-day is based, and it is of interest to note that the present building and organisation, large as they may appear, are only half of what was planned nearly fifty years ago. Two world wars disrupted the plans badly, and at the end of the last war the Museum found itself with only two-thirds of its pre-war space, some of its buildings being out of commission and beyond repair. Some new buildings have since been erected, and others are planned. This, very briefly, is the story which the first part of the book tells. The second section, which is much larger, deals with selected exhibits from the Museum's collection.

As anyone who has been to the Science Museum will know, the choice of a small, representative group of exhibits from the vast collection there must have been a very difficult one. A good many personal visits to the Museum are necessary even to get a fair overall idea of the number and historical value of the objects exhibited there, and the director, Dr. T. C. S. Morrison-Scott, and his staff have had to exercise considerable skill to choose just 21 examples from the great number at their disposal. The Science Museum is not only concerned with the history of science; its aim is to explain science generally, and to this end its exhibits are brought up to date. In the present instance, however, the emphasis is on history, and the exhibits chosen for description are all of historical interest. In them can be seen the origins or early stages of development of many things which are either commonplace to-day or which affect us all in some way or other, though we may not always be aware of their existence.

Thus we find the Wells Cathedral clock, of 1392, representing the measurement of time, and the Boulton and Watt rotative steam engine of 1788 showing the solution of the period to the ever-increasing demand for mechanical power. Dalton's diagrams of the elements (*c.* 1807), help us to realise that the study of atomic structures is much older than is generally appreciated, while some of the cumbersome photographic apparatus used by Fox Talbot from 1835 onwards may make the photographer of to-day thankful for the progress made in this field. There are examples, too, from the collection which make it clear that a specimen need not necessarily be a hundred years old or more to be of historical interest. History is simply a record of events, and yesterday's events may be of great historical importance. The Science Museum is, of course, well aware of this fact, and the book mentions, for example, Britain's first jet-propelled aircraft, the Gloster E28/39, which is illustrated with the Whittle W1 turbo-jet engine alongside it.

The other exhibits chosen for mention are equally interesting; ships, the steam turbine, radio, motor cars, the telegraph, and agricultural machinery are among the items represented.

There is really only one thing to do about the Science Museum—go and see it, often. For those who cannot, this book provides a fine cross-section of the exhibits, written and produced to the usual high standard of Science Museum publications. For those who can go, or who have been, and even for those who go regularly, the book is a valuable source of reference.

THE ART OF BEING UNDERSTOOD

English for Technical Colleges. By A. R. MOON. *Edward Arnold (Publishers), Limited, 41 Maddox-street, London, W.1.* (8*s.*).

The task of teaching English to student technicians and technologists is both difficult and delicate. It is difficult because English is not a technical subject with a syllabus, that is fixed in form and sequence by a necessary logical development, though technical students may not understand why English cannot be taught as directly as their technical subjects are. At first sight, therefore, the teacher appears to have a free choice of method and approach in trying to achieve his objective. But one heavy restraint is imposed upon his freedom: the imperative need to satisfy his students at all stages of the course that he understands their problems and is working towards a solution. These problems are rarely expressed explicitly, though they are often deeply felt; expressions of resentment and distrust are quickly evoked if the teacher deviates from what the students believe to be the direct approach.

The task is delicate because technical students are suspicious of the teacher whose background is wholly literary, since they feel that he does not understand their own technical language and, in consequence, that he cannot appreciate their linguistic difficulties. The teacher who shows undue enthusiasm for aspects of literature beyond the comprehension or appreciation of his students runs the risk of being thought to be hostile to science and, therefore, *a fortiori* to those who are concerned mainly with its practical application. Even an enthusiasm for grammar—the most technical aspect of English—can lead to loss of confidence between the teacher and his students. Nothing is more repulsive to those who do not understand it than technical jargon (as the teacher of English is the first to complain), but nothing is more repulsive to technical students than the technical jargon of grammar.

In recent years, many American treatises have been published on writing for technical students. Most of them have sought to reduce English to a technical subject by the minute analysis of standard forms of writing. One feels that the study of these treatises might enable students to answer examination questions on writing without teaching them to write. But Mr. Moon has not made this mistake. He recognises that the ability to write is a practical skill that can be acquired only by practice. Accordingly, his text-book is a sequence of exercises rather than an analysis of "the writing situation" or a compendium of recipes and formulae.

The sets of exercises are preceded by exposition with illustrative examples. The first main section covers the more frequent faults of grammar and syntax and is followed by sections on reading, summarising, letter writing, and oral and written reporting, with a concluding section designed to help students to expand their vocabularies. The expositions are short and straightforward. He avoids the formidable jargon of his own subject and writes, for example, about "welding sentences together" and the use of "pointers." His illustrative material is drawn from many sources, some literary and some technical (including several extracts from ENGINEERING). He thus implicitly demonstrates the fundamental unity of all forms of writing and at the same time reassures his technical students of his awareness of their special interest.

The value of such a book as this to the student is that it reduces the vague and tenuous subject of English to a compact and finite form, and thereby gives him a sense of purpose and direction which is too often lacking in English courses. Its value to the teacher is that it offers him a sequence of topics and exercises which have been evolved by an experienced teacher who has carefully studied his students. If the book has a serious fault it is that it may suggest to the student that it is more important to make statements correctly than to select the correct statements to make; but no text-book, however good, can provide the constructive criticism on which the successful teaching of English so heavily depends.

OBTAINING CONSTANT VOLTAGE

Voltage Stabilized Supplies: Basic Principles, Characteristics and Applications. By F. A. BENSON. *Macdonald and Company (Publishers), Limited, 16 Maddox-street, London, W.1.* (50*s.*)

The subject of voltage stabilised supplies has tended to be treated by electronics engineers as rather specialised knowledge until fairly recently when such devices as computers, microwave oscillators, electron microscopes and direct-current amplifiers—all requiring very stable power supplies—became more numerous and an increasing number of engineers found themselves involved in their design. The wide gap between the usual text-book approach and the detailed descriptions of particular circuits published in journals has been apparent and many engineers have felt the need for a middle-of-the-road book to ease for them the laborious job of locating, obtaining, reading and selecting references. Dr. Benson has recognised this need. With the aid of his book the problem when to stop reading and to start making can quickly be solved. The book contains a review of voltage stabilisation methods together with a comprehensive list of references to over a thousand published articles dealing with various aspects of the subject. For these two important features alone it will be much valued by its readers.

The production of a stable voltage source has occupied the attention of standards laboratories for a long time. The magnitude of the problems involved is shown by the fact that even now it is possible only to obtain standard cells whose voltage variations with temperature and time can be accurately predicted rather than be reduced to a negligible quantity. When power is taken from a bank of such cells the prediction is less accurate and their operation somewhat inconvenient. The artifices employed by the engineer to rid himself of these bubbling batteries have gradually improved until now the battery has been relegated to its proper space as an electricity store and other components employed to keep a voltage steady when it drives a fluctuating current.

The components in a stabilising circuit perform two functions: to produce an error signal from the difference between the set voltage and its actual value, and to adjust the voltage so as to reduce this error. Individual circuits differ only in the method of reducing this error with the appropriate elements for the voltages, power and accuracy required from the circuit. As would be expected, a considerable part of the book is devoted to voltage reference devices—the critically important component of a stabiliser circuit as far as accuracy is concerned. The results of investigations into the characteristics of glow-discharge tubes and into the voltage stability of primary and secondary cells, occupying together about a third of the text, include much detailed information that has not previously been published.

The remainder of the book discusses thermionic-valve stabilisers, power supplies for microwave oscillators, corona and other discharge tubes, and stabilisers employing magnetic saturation. In the chapter "Miscellaneous Circuits" a wide variety of practical circuits for alternating as well as direct voltage stabilisation, ranging from heater supplies to a 500 kV supply for a pulsed proton beam, are given. Judicious use of algebra is made to analyse their performance and actual measured figures for circuits are given. Although the suitability of this book for student use is open to question on the grounds of its profuse detail obscuring general principles, there can be no doubt about its utility to research workers and practising engineers.

★ ★ ★

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Machinery for Ceramics, Chemical and Process Industries. WILLIAM BOULTON LTD., Providence Engineering Works, Burslem, Stoke-on-Trent. Kilns, filter presses, rotary screens, stonebreakers, elevators and conveyors, mixers, potters' lathes, autoclaves, presses for refractories, dryers. Continuous wet grinding system to extremely close limits; new gyratory screens claimed to be faster, more efficient and to give better material distribution. Well-bound illustrated descriptive brochure, including technical data section; and individual illustrated leaflets.

Helical Membrane Cables. TELEGRAPH CONSTRUCTION AND MAINTENANCE CO. LTD., Theobalds-road, London, W.C.1. Telecon helical membrane cables for radio-frequency application. Details of advantages, mechanical construction and method of manufacture to give economy, high electrical uniformity and good screening. Illustrated brochure.

Plugs, Sockets, Joints and Terminations. TELEGRAPH CONSTRUCTION AND MAINTENANCE CO. LTD., Theobalds-road, London, W.C.1. A series of connectors, plugs, sockets and terminations designed for use with Telecon radio-frequency cables, although some have a more general application. The inner socket is of beryllium-copper to ensure low contact resistance. Telecothene is used as an insulant for the plugs and sockets and special ceramics in the terminations. Full technical details. Illustrated pamphlet.

Pneumatics and Hydraulics. BALDWIN INSTRUMENT CO. LTD., Brooklands Works, Dartford, Kent. "Fluid power"—pneumatic and low-pressure hydraulic equipment for heavy-duty industrial applications—power cylinders, control valves, pilot valves, and accessories. Illustrated brochure with technical descriptions and tabulated data sheets.

Stepping Relay. D. ROBINSON AND CO., 58 Oaks-avenue, Worcester Park, Surrey. Stepping relay with zero re-set for use as a selector or with counting and memory device. Twenty-one way single-pole or 10-way double-pole patterns. Operation direct from alternating current circuit, the consumption being only 45 volt-amperes. Illustrated catalogue.

Germanium Devices. STANDARD TELEPHONES AND CABLES LTD., Rectifier Division, Edinburgh-way, Harlow, Essex. Germanium junction power rectifier type RG50B, rated for 30 mA at 115 v. r.m.s. input at temperatures below 35 deg. C. Also photo-electric cell PG40B with sensitivity of 30 mA per lumen. Leaflets F/GER103 and 104 respectively.

Plastics Preheaters. RADIO HEATERS LTD., Eastheath-avenue, Wokingham, Berkshire. Radyne radio-frequency preheaters for plastics moulding; claimed to increase production up to three or five times and to enable larger mouldings to be made on existing presses. Illustrated brochure with technical data and specifications.

Temperature Recorder. BAILEY METERS AND CONTROLS LTD., 153 Moorgate, London, E.C.2. Strip chart temperature recorder for use with a thermocouple or resistance element. Up to four separate records in different coloured inks. Driven by a synchronous motor. Illustrated leaflet No. E51–8.

Air Filters. STURTEVANT ENGINEERING CO. LTD., Southern House, Cannon-street, London, E.C.4. "Fleetway" air filter incorporating a paper element. Various sizes with capacities up to 1,000 cub. ft. per min. Efficiencies up to 99·75 per cent. obtained in regular service. Publication No. 4003.

Decorative Aluminium Sheeting. BRITISH ALUMINIUM CO. LTD., Norfolk House, St. James's-square, London, S.W.1. "Imprest" decorative aluminium sheet, from 14 s.w.g. to 18 s.w.g., maximum size 6 ft. by 3 ft. Two qualities, for lacquering or for anodising. Illustrated leaflet.

Transformers. STANDARD TELEPHONES AND CABLES LTD., Rectifier Division, Edinburgh-way, Harlow, Essex. Single- and three-phase transformers, 15VA to 37·5 kVA. Open-shell, open-core, bracket, potted or hermetically-sealed types. Leaflets F/TRL 55 to 61.

Silicon Rectifiers. STANDARD TELEPHONES AND CABLES LTD., Rectifier Division, Edinburgh-way, Harlow, Essex. Low-power silicon junction rectifiers, three types for maximum inverse voltages of 50, 100 and 150 volts. Forwards currents up to 0·50 amp at 35 deg. C. Leaflet F/SIL 101.

Flow Controller. G. A. PLATON LTD., 323A Whitehorse-road, Croydon, Surrey. "Flostat" automatic flow controller incorporating a differential-pressure flowmeter and a double-beat control valve. Leaflet B.G.I.

Air Filters. FIBREGLASS LTD., Ravenhead, St. Helens, Lancashire. Glass fibre filters for removing dust particles from 5 microns to 22·5 microns in air stream up to 450 ft. per minute. Technical data and specification leaflet.

Wall Charts. ADAPTA CHARTS, LTD., 129 Hammersmith-road, London, W.14. The versatility of the "Movigraph" range of wall charts is described in an illustrated leaflet.

On the Shelf

By Frank H. Smith

It is surprising, the unlikely places that one finds a "Great Truth." For instance, in *The Shell Magazine* there is a contributor, B.W.S., who writes humorous material which is a cross between *The Economist's* Parkinson's Law and Stephen Potter. In the August issue he writes on "The Old Boy Network" and describes the usefulness of personal contact in short-circuiting official lines of communication. In doing this, he maintains a wonderful chain of metaphor, involving ebb-tides, locks, channels and other things. And then he says "I can only repeat that such things as conferences, courses and trips are not only estimable in themselves but invaluable as means of acquiring more and better Contacts." The only point at which I differ is the inclusion of the words "not only estimable in themselves, but."

New ground seems to be broken with *Interpas Monthly Patent Data* from International Patent Service, c/o N. V. Ahex, Lange Poten 15a, The Hague, The Netherlands. This publication lists the patents of 21 countries according to certain classes, the classification of which was determined at Paris in December, 1954. The complete specification is not, of course, given but a coding enables one to apply to Interpas who will supply the full material at cost, plus postage, plus 20 per cent. The bulletin consists of double sheets divided into 18 columns giving such particulars as country of origin, patent number, date of grant and other relevant dates, the patentee's name and address, the title of the patent, and so on. English is the language chosen but it is proposed to publish in German and French should the demand justify this. The specimen copy which I have received covers "Glass Grinding and Polishing" and runs to 13 double pages. These have the data on one side only to enable them to be pasted on to 21 cm. cards. Interpas have re-classified the international scheme into 148 groups, of which my 13 sheets represent only two. It will be seen, therefore, that the monthly instalment is a not inconsiderable undertaking which should save patent researchers quite a lot of hard labour. It is difficult to describe fully the service and I would suggest that any reader whose appetite is whetted should apply to The Hague for particulars.

The National Smoke Abatement Society has been in existence since 1898 and it must be very gratifying to them to see, at last, some notice being taken of their long agitation for clean air. The Society is to publish, experimentally, a duplicated news bulletin called *Air Pollution News*. This will not appear at fixed intervals but will supplement the regular quarterly, *Smokeless Air*. Further details may be had from the Society at Palace Chambers, Bridge-street, London, S.W.1.

The Press release sent out in connection with the annual report (1955-56) of the Department of Scientific and Industrial Research is headed "Progress with the Five-Year Plan." I wonder why that phrase "Five-Year Plan" almost inevitably gives a quite innocuous programme a rather grim atmosphere? Or am I too sensitive?

The July *B.S.I. News*, issued by the British Standards Institution, gives, with some pride, preliminary plans for next year's International Organization for Standardization plenary session to be held at Harrogate. This will be the first such I.S.O. meeting in this country. A beautiful air view of Harrogate is given at the head of the article with a caption which starts "Where every prospect pleases." It is to be hoped that the delegates will not ask for the next line of the quotation.

The four main societies concerned with shipbuilding have formed the Joint Nuclear Marine Propulsion Panel and the first number of the *Journal of the Joint Panel on Nuclear Marine Propulsion* is dated April, 1957. This contains a glossary, short descriptions, with diagrams, of the different types of nuclear reactors and a paper on "Some Safety Considerations of Nuclear Power Reactors." Is it not refreshing, these days, for consideration to be given to precautions before all else? It is intended that the *Journal* shall be issued in October and April and particulars can be obtained from the secretary of the Institute of Marine Engineers, 85/88 The Minories, London, E.C.3.

I am always interested, when I get the annual report of a Government Ministry or department, to read through the list of "papers published elsewhere," which is usually given at the end of each chapter. There is often something out of the ordinary as, for instance, in the Meteorological Office's report for 1956-57 (H.M.S.O., 3*s*.), a Mr. Hogg's paper on "Weather and the Incidence of Chocolate Spot on Beans." But the report is really full of interest and surprise, even to the untutored reader and deserves a place in all reading rooms so that those who complain will appreciate that the Met. Office has other things to do than prepare the weather forecasts which nobody believes but everybody relies on.

Design

DATA ON HUMAN PERFORMANCE FOR ENGINEERING DESIGNERS

Continued from page 249

By K. F. H. Murrell, M.A., F.R.P.S.

The direction of movement of a control should be compatible with the movement of the display which results. That is, the display movement should be "expected." A number of control-display relationships have been established as being expected by most operators and these are known as population stereotypes.

CONTROL-DISPLAY RELATIONSHIP

There are also movements not associated with displays which appear to be expected. For instance a door knob turned with the right hand is expected to turn clockwise, as also is the on-off knob of a radio receiver even when there is no immediate result. This may be because turning the right wrist clockwise from the natural rest position with the back of the hand uppermost is easier than turning it anti-clockwise. Slightly more force can be exerted clockwise also. While this may hold good for most people there are some apparent stereotypes which belong to a particular population, and these would seem to be usually the result of learning. For instance in this country a light switch is moved down for "on," in America it is moved up. If either method can be said to have more virtue than the other it might be the American on the basis of the "up to increase" stereotype.

The operation of equipment into which expected relationships have been designed will be learned more quickly than when the relationship is unexpected. Given long enough the performance on both may ultimately be the same, but what is of even more importance is that in emergency an operator, however well he has learned an unexpected relationship, is likely to revert to an expected relationship and disaster may result. These effects seem to be more pronounced in older people. An example of this occurred on a hydraulic press where a downward movement of a lever produced an upward (unexpected) movement of the platen. An emergency arose and the operator wishing to raise the platen pulled the lever up wrecking the press.

Expected relationships which have been established are:—

With levers. Up or forward to increase or move up; Right to increase or move right.

With rotary controls. Clockwise to increase or move right, up or away.

With a rotary control the part of the knob or hand wheel nearest to an associated dial should move in the same direction as the pointer, and the movement of a lever should follow the movement of the pointer (see Fig. 24). This relationship can often be achieved only by moving the position of zero on a normal gauge (Fig. 25).

Valves which turn anticlockwise to open (or increase pressure) are a difficulty. There is evidence that when a valve is alone in a system of pipework anticlockwise-to-open may be a population stereotype, but that when the handwheel of a valve is mounted in a panel, with an associated gauge, the operator will follow the pointer and revert to the expected movement of clockwise-to-increase if a normal gauge is used with the pointer moving left-to-right across the top of the dial. This difficulty can be overcome by moving the zero to 12 o'clock so that the normal working position will be in the bottom half of the dial and the pointer will move right-left for an increase associated with an anticlockwise movement of the hand wheel. Alternatively, a horizontal edgewise gauge can be used increasing from right to left. (Fig. 26.)

This arrangement cannot be used safely in panels which contain both pressure and electrical controls. Controls which produce different results from the same direction of movement should never be used together. Similarly, if a plant may need to be shut down in emergency the same movement should be established for all controls whether they open or shut valves; left hand threads should be used where necessary to achieve this.

To sum up:—

(*a*) Design equipment so that there is an "expected" relationship between controls and movement of machine or pointer of dial or indicator. Where the "expected" direction is not clear for any particular equipment, the equipment should be re-arranged until it is clear.

(*b*) All controls on a given equipment whether used with or without dials should produce the same effect from the same movement.

(*c*) All controls used for a given purpose, for example, starting up or closing down a plant, especially in emergency, should move in the same direction.

(*d*) A good control-display relationship once established should not be altered and should be standard on all equipment in which it is found.

CHOICE OF CONTROLS

Hand operated controls are in general more precise than foot operated controls. Fore and aft hand movements are slightly more precise than right-left or rotary movements. Precision

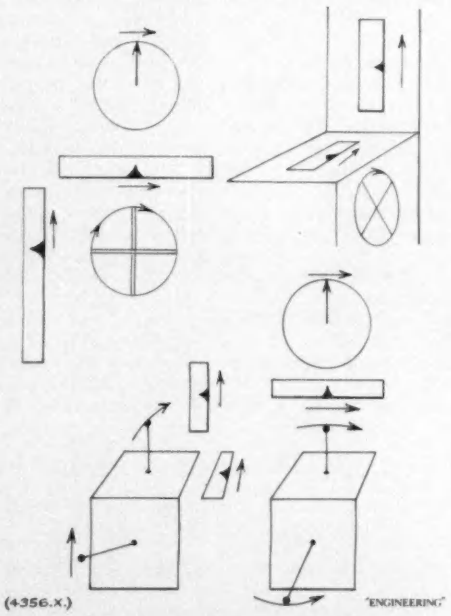

Fig. 24 The movement of a handwheel or lever should be in the same direction as the pointer with which it is associated.

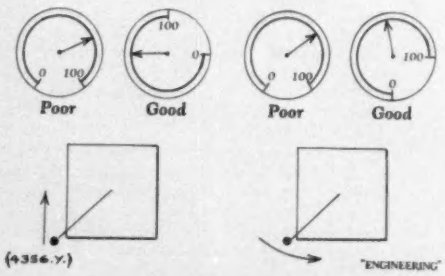

Fig. 25 By moving the position of the zero on a gauge, a better relationship between pointer movement and control movement may be obtained.

of hand movement decreases the further the hand is away from a point close to the body and opposite the shoulder, or above or below elbow level.

The choice of the control to be used may be influenced by the relationship between the control and its associated display (see the section on display-control relationship).

Rapid Control with Accurate Adjustment.—Use cranks or levers. Precise movements can be made at the end of a fore-and-aft movement of a lever when the hand is near the body. Precise movement cannot be made with a crank alone, it should be mounted upon the rim of a hand wheel with which final fine adjustment can be made.

Rapid Control without Accurate Adjustment.—Use cranks or levers where some form of coarse adjustment is required. Use push buttons or pedals where the movement is of the "on-off" kind.

Slow Movement.—Use hand wheels when the load is above about 22 in.-lb. and knobs when it is below. Use a pedal when a final adjustment required is less precise. Use a lever when the load is light and the movement required is greater than can be obtained by about a half turn of a knob. A lever should never be used if the operator is liable to be jolted.

Multiple Switching.—Use a joystick in preference to a series of push buttons or knobs when rapid switching is required. The feet cannot be used for rapid multiple switching, and combinations which require almost simultaneous multiple switching by both hands and feet should not be used.

Control Movements with a Load.—For medium loads with short travel use a vertical lever when the load is up to 100 lb. and a horizontal lever when the load is below 30 lb. (seated operator). For medium or heavy loads with long travel use a large single or double crank or a handwheel. For maximum loads these should be operated from the side. For heavy loads with short travel use a vertical lever and standing operator. The operator may have to use his body weight and this will determine the load. The lever should be pulled against the load and a foot rest provided against which he can brace himself. *But do not use this type of control unless it is unavoidable.*

Simultaneous Control in Two Dimensions.—Use a joystick or two knobs. When tolerances are large there is unlikely to be much difference between the two but when tolerances are small the knob control is superior to the joystick. (Left hand facing knob; clockwise—right. Right hand side knob; clockwise—up : see Fig. 27.)

DESIGN OF CONTROLS

Where maximum forces are given in the data which follow they should be called for only under very exceptional circumstances. For normal repetitive operations forces of not more than half the maximum should be required. The forces which can be applied by the non-preferred hand (the left hand of a right-handed operator) are about two thirds those of the preferred hand. Females can be expected to exert about two thirds the force of a male.

Cranks

Definition.—A crank is a control in which the part gripped by the hand is parallel to the shaft as in a car starting handle.

Use.—Cranks should be used when turning speeds are high—up to 200 r.p.m.; when rapid complete turns are required; with heavy loads.

Size.—For rapid continuous cranking of 150 to 200 r.p.m. under light loads up to about 5 in.-lb. the optimum diameter is 2½ to 3 in. The

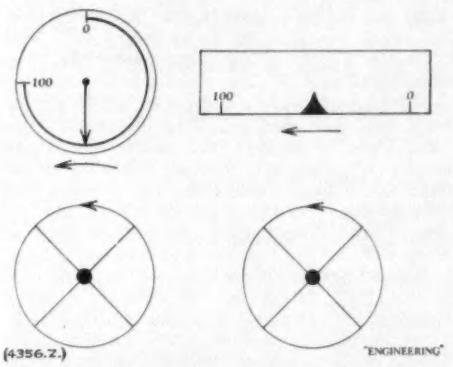

Fig. 26 Anti-clockwise controls call for special treatment. Two solutions are possible: the zero can be moved, as shown, or a horizontal edgewise scale can be used.

rate of turning decreases as the diameter increases above this size. For example, when turning for 5 seconds with the preferred hand the rates in Table V were obtained. Individuals vary greatly in cranking speed but the general trend is indicated.

TABLE V.—*Maximum Cranking Rates*

Diameter in.	Max. rate (horizontal) r.p.m.
1·2	260
1·6	270
2·4	275
4·0	255
5·6	235
9·6	185
19·2	140

The preferred hand is faster than the non-preferred hand. Direction of rotation does not appear to affect the rate. For single rapid full turns suggested minimum crank diameters are given in Table VI. (After Davis[24].)

TABLE VI.—*Minimum Crank Diameters*

Torque	Vert. facing 36 in.	Vert. facing 48-58 in.	Horizontal 36 in.	Side 36 in.
0 in.-lb. up to	3 in.	5 in.	3 in.	3 in.
20 in.-lb. up to	5 in.	5 in.	9 in.	9 in.
40 in.-lb. up to	9 in.	9 in.	15 in.	15 in.
60 in.-lb. up to	9 in.	9 in.	15 in.	15 in.
90 in.-lb. up	9 in.	15 in.	15 in.	15 in.

Effect of friction and inertia are given in Table VII.

TABLE VII.—*Effect of Friction on Cranks*

	Intermittent winding	Continuous winding
Friction viscous..	Has an adverse effect	2-5 lb. desirable.
Inertia	No research known on this but may be assumed to be undesirable	Especially valuable in presence of friction. Maximum 10 lb. force on crank to obtain maximum acceleration.

Gear Ratios.—If maximum accuracy is required when " tracking " gear ratios should be selected to give the highest convenient winding speed—about 180 r.p.m. for a 3 in. crank. (Note: these high winding speeds can be maintained for only about 30 seconds.)

When range of winding speed is greater than 2 : 1 there should be a choice of gear ratios: high for rapid slewing, and low for making fine adjustments.

Handle Shape.—A crank handle should have parallel sides with a slight indentation at the inner end; bulbous handles are poor. Length—1½ in. moderate load; 3½ in. heavy load.

Type of Crank.—For rapid continuous cranking a vertical facing crank is to be preferred to a horizontal or side crank. For slow positional tracking (accurate continuous turning at a rate rather above 1 r.p.m.), it has been suggested that cranks rate in the following order:

(i) A two-handed side crank.
(ii) A single-handed side crank.
(iii) A single facing crank, vertical or inclined.

Handwheels

Definition.—A handwheel is a control gripped by the rim, as in a car steering wheel.

Use.—Handwheels should be used only when turning speeds are 1 r.p.m. or less; when accurate partial turns are required; when the load is too great for a knob operated by one hand.

Size and Position.—For a standing operator the optimum height above the floor is about 40 in. The optimum position is with the shaft facing the operator or at 45 deg. below the horizontal (— 45 deg.). Wheels should not be used sideways-on to the operator except when a force of about 170 lb. must be exerted. Table VIII gives the optimum sizes of handwheels when used for partial turns. (After Davis[24].)

TABLE VIII.—*Optimum Size of Handwheels for Partial Turns*

Torque	Wheel diameter at 38-48 in. high	Below 38 in. or above 48 in.
20 in. lb. up to ..	6 in.	10 in.
40 in. lb. up to ..	10 in.	16 in.
60 in. lb. up to ..	10 in.	16 in.
90 in. lb. up ..	16 in.	16 in.

For a sitting operator using a vertical facing wheel with both hands the best size of wheel is about 12 to 14 in. in diameter, with its axis 18 in. above the top of the seat placed 12 to 18 in. from the seat back.

Maximum control is obtained when both hands are used gripping the sides of the wheel. The maximum tangential force which can be applied with both hands in this position is of the order of 80 lb.; it is rather less than half this with one hand on the side of the wheel. A slightly greater force (by about 20 lb.) can be applied in an anti-clockwise direction than in a clockwise direction.

Knobs

Definition.—A knob is a rotary control which can be operated only by gripping it on both sides with one hand.

Use.—Knobs should be used for making fine adjustments when loads are light; for some switching operations.

Size and Load—Continuous Function.—For light loads a cylindrical knob is best. For loads above about 13 in.-lb. a four-pointed star is best, and more force can be developed with a side knob than with a facing knob or a horizontal knob. For a force between 13 and 17 in.-lb. the diameter should be 3 in. and for a force between 17 and 22 in.-lb. it should be 4 in. A side knob may have a diameter between 1·0 and 2·0 in. (optimum 1·6 in.). A facing knob may have a diameter between 1·0 and 3·5 in. (optimum 2·0 in.), the optimum load is 2 in.-lb. and the maximum load 11 in.-lb. The maximum diameter of a cylindrical knob which can be gripped by the fingers is 5½ in.

Size and Load—Step-Function.—Use bar-shaped knobs 1 to 3 in. in length, protruding not more than 1 in. from panel. Maximum load, 2 lb. Minimum separation between positions, 45 deg.

Gear Ratios, Friction and Inertia.—Knobs used for fine adjustments to locate a null position (as in tuning a radio receiver) should have a gear ratio such that they move about 60 to 80 deg. between a just detectable misalignment in one direction and a just detectable misalignment in the other.

When used for making accurate settings on a linear scale with a tolerance of about 0·007 in., one turn of a knob should produce a 1 in. to 2 in. travel of the pointer. This ratio applies equally when friction or inertia are present if the travel is small. A larger knob will not compensate for too coarse a ratio nor will the use of a crank compensate for too fine a ratio—the use of a crank may actually be detrimental.

When the distance of pointer travel is large (i.e., 9 to 12 in.) or friction is present, a knob diameter greater than 2 in. should be used with a higher ratio. Under these circumstances inertia compensates for friction. With a tolerance of about 0·016 in., pointer travel should be about 4 in. and with a tolerance of 0·001 in. it should be about 6 in. for one turn of the knob. Knobs with attached indices should be mounted so that the index is close to the panel surface and clear of the fingers.

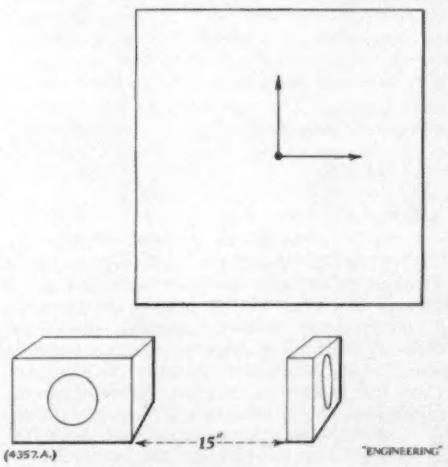

Fig. 27 For two-dimensional movements with small tolerances, knobs are superior to joysticks. Rotation should be clockwise on both circles.

Levers

Definition.—A lever is a hand-operated rod-like control working about a fulcrum in one dimension.

Use.—A lever may be used when the effective travel is short; when speed of movement and not accuracy is required; when the load is medium to heavy; when rapid switching with or without a load is desired.

Horizontal Lever Pulled up or Pushed Down.—The greatest pull can be exerted on a horizontal lever when it is at the average hand height (28 to 30 in. above the floor for a standing adult). The force which can be exerted falls off rapidly at greater heights and as the lever is lowered down to about 17 in., when it increases again.

The force which can be applied will vary with the individual but may be as much as 100 lb. with one hand. (In general, if a force of more than 30 lb. must be exerted mechanical assistance should be given—especially if accurate movement is required.)

When a lever is pushed down by a standing operator he can bring a large proportion of his body weight to bear. This is undesirable and forces in excess of 40 lb. should not be demanded of either a sitting or a standing operator. The handle of the lever should be placed so that the arm is straight at the end of the travel of 6 to 7 in. maximum.

Vertical Lever Pushed Away From or Pulled Towards the Body.—The optimum position for a lever to be pulled or pushed one handed is opposite the shoulder of the arm which is to operate the lever. Levers to be operated with both hands should be placed centrally to the body.

The force which can be applied falls off rapidly as the lever is moved to either side of these positions. When a lever operated by the right hand is opposite the left shoulder the force is decreased by about one-third. Maximum pull can be exerted when the arm is fully extended, and maximum push when it is bent at 135 deg.

For a seated operator provided with an adequate footrest:

Optimum height of handgrip above seat ..	9 in.
Maximum " " " " " ..	15 in.
Position of maximum pull (average operator)	35 in. from seat back
Position of maximum push	29 in. from seat back
Maximum pull by preferred hand ..	at 35 in. about 120 lb

Continuing Design

Maximum pull by preferred hand	..	at 29 in. about 75 lb.
,, ,, ,, ,, ,,	..	at 22 in. about 45 lb.
,, ,, ,, both hands ..	..	at 33 in. about 120 lb.
Maximum push by preferred hand	..	at 29 in. about 130 lb.
,, ,, ,, ,, ,,	..	at 22 in. about 160 lb.
,, ,, ,, both hands ..	..	at 29 in. about 240 lb.

If accurate movement is required, forces of not more than 30 lb. should be called for. It will be noted from the above that the distance of travel over which maximum force can be applied is quite short—about 3 in.

Vertical Lever Moved Across the Body.—It is easier to apply force inward across the body than outward. The optimum distance of the lever from the body appears to be about 18 in. and the force falls as the distance is increased to 20 in., which is the greatest distance a lever should be from the body. The maximum force which can be applied across the body from a central position with one hand is about 45 lb. and outward about 30 lb. With two hands, either to right or left, about 70 lb. can be applied. The force decreases rapidly as the lever moves from the central position.

When used in conjunction with a horizontal scale the free end of the lever should move three to four times faster than the pointer, irrespective of the length of the lever. The maximum movement across the body is about 38 in. Thus scales longer than about 12 in. should not be used with levers of this type.

Toggle Switches.—The maximum force for operating toggle switches or miniature levers up to 1 in. in length, should be between ½ lb. and 1 lb. They should be used only for switching. There should be a movement of about 30 deg. either side of the central position, otherwise there may be difficulty in seeing their position. " On " should be forward, to the right, or down for equipment to be used in the United Kingdom, and up for equipment to be used in the United States.

Joysticks

Definition.—A joystick is a lever working in two dimensions.

Use.—A joystick should be used when simultaneous control in two dimensions is required or for rapid multiple switching operations.

Short Sticks Used with Light Loads.—It is suggested:

(*a*) that a vertical stick is superior to a horizontal stick because it supports the weight of the hand and arm; (but see control-display relationship)

(*b*) that a vertical stick with the free end down and held in the fingers like a pencil is superior to a stick with the free end up.

If a horizontal stick is used the elbow of the operator *must* be supported.

A positional control can be learned and operated more quickly and accurately than a rate-aided control or velocity control. Movement towards the body can be made more accurately than movement away from the body. Push-pull is more accurate than left-right or up-down. The maximum length of a joystick should be about 9 in., and the travel of the free end 6 in. Viscous friction of about 2 lb. should be used to minimise the effect of jolts.

For use in velocity control systems, it has been shown that a pressure-operated joystick (a joystick which is constrained so that its only movement is slight " give " in response to increasing pressure) is superior to a free-moving joystick. This superiority seems to be most marked in those systems where the visual changes in the display do not clearly define the response required (for example, with compensatory tracking). When the visual cues are more adequate, as in positional control, this superiority may be less marked. For specific situations, refer to the original texts.[25]

Long Sticks with Heavier Loads.—Force called for in lateral direction should be less (10 lb.) than that in the fore and aft direction (20 lb.). The maximum force which should be called for in either direction is 30 lb. (this follows from the forces which can be applied to levers at varying distances from the body). If a greater force is required some mechanical assistance should be given.

If a joystick operated by both hands is placed asymmetrically in relation to the centre line of the operator's body, there will be a tendency for the operator to over-correct towards the centre of the body. The handle of the stick should be 8 to 10 in. above seat height and approximately 19 to 30 in. from the seat back. Lateral movement should be not more than 7 in. each side of neutral, 5 in. fore, and 9 in. aft.

Joysticks Used for Switching.—The length should be 6 to 8 in. The distance of travel of the extremity should be 2 to 3 in. The force required to overcome any spring centring should be about 2 lb. The optimum number of switch positions is 4, the maximum is 8.

Pedals

Definition.—A pedal is a reciprocating control operated by one foot acting independently.

Use.—Pedals should be used when a powerful force is required; for continuous controlling when the accuracy required is not of a high order; for on-off or start-stop switching. Pedals may be divided into those where force is obtained from movement of the leg and those where force is obtained from movement of the ankle.

When torques of above 20 in.-lb. are required a pedal should be operated by the use of the leg; for less than 20 in.-lb. it should be operated by the foot, pivoted at the ankle.

Pedals Operated by the Leg—Seated Operator.

(*a*) *In Line with the Lower Leg.*—The maximum force can be applied when the leg is not quite straight—when the knee is bent at about 165 deg. In this position forces as high as 700 lb. can be applied, but normally not more than 200 lb. should be called for. The movement of the pedal should be in line with the leg, and the pedal should be about 4 in. above or below the level with the seat top—its travel should be about 4 to 6 in. To cover the 90 per cent. range of male operators, seat back should be 41 in. from the fully depressed pedal with range of adjustment of ± 3 in. For women the distance should be 38 in. with a similar range. The back rest should be 7 to 8 in. above the seat which should have a backward slope of 5 to 15 deg. The unused leg should be supported.

The pressure should be applied by the front of the heel or the arch of the foot. The toe should never be used since it strains the foot extensors. As the leg becomes more bent, so the thrust decreases—as shown in Table IX. Greater forces than these can be exerted but only when the trunk is moved forward in order to bring more weight over the pedal. This is normally undesirable and may even cause physical damage to the operator. If forces greater than those given in the table are unavoidable the operator must stand and use his body weight.

TABLE IX.—*The Ability of the Leg to Thrust*

Knee angle	Backrest			No Backrest	
	Sustained thrust without discomfort	Max. instantaneous thrust		Max. instantaneous thrust	
		Without strain	With strain	Without strain	With strain
135 deg.	50 lb.	80 lb.	155 lb.		
113 deg.	45 lb.	60 lb.	90 lb.		
90 deg.	30 lb.	50 lb.	60 lb.	30 lb.	40 lb.

(*b*) *At Right Angles to Lower Leg.*—A lever operated by swinging the lower leg backward or forward should be only as long as the lower leg (17 in. for men; 15 in. for women). Otherwise the body must make complicated adjustments to permit displacement of the pedal. The maximum force which can be applied by bending the knee is about 65 lb. for men and 45 lb. for women; by stretching the knee, 90 lb. for men and 65 lb. for women.

Pedals Operated by the Leg—Standing Operator.—In the standing position the greatest force is obtained when the weight is directly over the pedal and the leg is straight, i.e., the pedal at the end of its travel should be at floor level. The maximum height of the pedal above the floor should be 9 in.

If the leg operating a pedal is to remain resting on it while not working, there should be sufficient force to support the weight of the leg since it is undesirable that the operator should have to actively keep his leg raised. The average weight of the lower leg is 6 lb. and the thigh 13 lb. This type of control is undesirable since it forces the operator to stand on one leg.

Pedals Operated by the Foot.—Pedals operated by the foot should not be used by standing operators except under very unusual conditions. From anatomical considerations, the ideal pedal should be fitted with a stirrup so that its pivot is in line with the ankle bones. This will usually be mechanically inexpedient; a pedal with the hinge under the heel is to be recommended for most purposes.

The maximum movement of the ankle is about 30 deg. above and 45 deg. below a position at right angles to the shin bone. But these maxima may represent a position of strain, and foot pedals should be designed so that no movement larger than 20 deg. up or 30 deg. down is called for. In practice this means that the maximum height of a pedal above the heelrest should normally be 3 in. when the lower leg is vertical. The load on the pedal should be sufficient to support the weight of the foot—about 2 to 3 lb. It should not be greater than 7 lb. Avoid large movements of the foot when transferring from rest to pedal.

Push Buttons

Definition.—A push button is a reciprocating control, small in size, which has a positive action in one direction only.

Use.—Push buttons should be used for switching in one sense.

Operated by the Foot.—Range of movements and loads given for pedals apply equally to push buttons operated by the foot.

Where foot has to be transferred from rest on to a push, have top of push level with footrest if possible. A push should be operated with the sole of the foot in preference to the side of the foot.

Operated by the Hand.—The maximum pressure should not exceed 30 lb. but normally it should be well below this. The movement should have a positive action and the operator should be able to feel when the movement has been completed by a change in load or a " click." If there is any danger of the button being pressed accidentally it should be recessed or guarded by a raised rim. The surface of a button should be larger than the surface of finger. For coding of controls by touch see under Tactual Displays.

To be continued

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55 H.P. GAS-TURBINE ENGINE

The Solar Aircraft Company, San Diego, are designing and preparing to produce what is believed to be the smallest aircraft gas turbine ever built. Only 20 in. high, with a maximum diameter of 15½ in., and weighing only 50 lb., the engine will produce 55 s.h.p., plus 12 lb. jet thrust. It is to power a one-man helicopter, and is the first to be designed and built by Solar specifically for aircraft propulsion. The engine will operate on standard military fuels, and the rotor will spin at 57,600 r.p.m.

The company is to produce the new engine under a joint contract from the Navy Bureau of Aeronautics and the U.S. Army. Known as the Solar Mercury, the engine's military designation is the YT-62.

Continuing **Design**

THE RATIONAL METHOD FOR ESTIMATING FLOOD PEAKS*

IRISH CONTRIBUTIONS TO THE TECHNIQUE

By James C. I. Dooge, M.E., M.SC., M.I.C.E.I.†

Hydrology has been defined as that part of science which deals with the occurrence and behaviour of water, above, on and under the surface of the ground. As it exists to-day, hydrology is an earth science with important applications in many branches of civil engineering. One of the key problems facing the hydrologist is the prediction, for a given catchment area, of the peak flow likely to occur as a result of heavy rainfall. In the case of catchments in urban areas, or small catchments in rural areas, the method most frequently used is that commonly known as the "rational method." This method is used in determining the size of trunk sewers, surface drainage channels, highway culverts and bridge waterways.

The essential feature of the rational method is that the run-off is calculated for a storm, the duration of which is equal to the time of concentration of the catchment, i.e., the time taken for the first drops of rain falling on the most remote part of the catchment to travel to the outlet. Nearly all British writers have referred to this method as the Lloyd-Davies method, and cite as the classical reference a paper entitled "The Elimination of Storm Water from Sewerage Systems," which appeared in the *Proceedings* of the Institution of Civil Engineers in January, 1906. American writers date the method from a paper by Emil Kuichling, entitled "The Relation Between the Rainfall and the Discharge of Sewers in Populous Districts" (to which Lloyd-Davies makes reference). Kuichling's paper was published in the *Transactions* of the American Society of Civil Engineers in 1889.

During the past twelve months, the present writer has examined a large amount of material relating to the history of arterial drainage in Ireland between 1842 and 1862. It is now evident, as a result of this research, that the rational method was proposed and clearly set out by an Irish engineer, Thomas J. Mulvany, in February, 1851. In addition, sufficient material has been discovered to enable the important steps in the evolution of this particular method of flood estimation to be traced.

The present paper describes the attempts of a group of Irish engineers, working more than 100 years ago, to develop a satisfactory method of predicting the peak rate of run-off from a small catchment. In a short period of ten years (between 1842 and 1852) many of the essential characteristics of flood hydrology were clearly discerned by them. The various steps from a state of virtual ignorance to the fully developed rational method can be clearly traced.

HYDROLOGY PRIOR TO 1842

At the start of the period under review, knowledge of the relationship between rainfall and streamflow was meagre indeed. Hydrology had only just emerged from the phase in which a prime point of debate was whether rainfall was adequate to supply streamflow. Quantitative relationships between run-off and storm rainfall were unheard of, and the gradual emergence of such relationships is the main topic of the present paper. This lack of information on hydrology is in marked contrast to the situation in regard to hydraulics. In the case of the latter science, development was much further advanced, mainly as a result of the efforts of Italian and French engineers. Their work was known to English-speaking engineers through comprehensive articles in the *Edinburgh Encyclopedia* (1830) and *Encyclopædia Britannica* (1823 and 1842), and more particularly through the comprehensive reports made by George Rennie to the British Association in 1833 and 1834. These and similar sources yield no information on hydrology except for a general qualitative understanding of the hydrological cycle and some isolated measurements of rainfall and evaporation.

The ancients believed that rainfall could not be the source of springs and streams, because rainfall was both insufficient in quantity and incapable of penetrating to any appreciable distance below the surface of the ground. The ideas of the Greeks on the origin of springs were clearly influenced by their familiarity with cavernous limestone terrains. Plato speaks of a vast cavern called *Tartarus*, which is the origin of all springs and streams, and to which all waters return. Aristotle recognised the existence of percolation, but considered that the greater part of the flow from springs was due to a process of condensation under the surface of the ground. Most Roman writers on the subject follow either Plato or Aristotle, though Vitruvius correctly ascribed the supply of springs and streams to the percolation of rain and snow which had fallen on higher ground.

Throughout the Middle Ages and down to the end of the Seventeenth Century, the hypotheses of Plato and Aristotle held sway to the exclusion of the percolation theory. The latter viewpoint was held by some writers, notably Leonardo da Vinci (1452-1519), who encountered the problem when designing canal systems near Milan, and Bernard Palissy (1509-1589), better known as a potter. About 1670, the rainfall and the run-off in a portion of the Seine catchment were estimated on the basis of actual measurements. The quantity of rain and snow was computed to be over six times the quantity of run-off from the catchment. This and similar results led to the gradual adoption of the percolation theory.

During the Eighteenth Century the main progress was in methods of measuring the velocity of stream flow—notably Pitot's tube in 1723 and Woltman's current meter in 1790. The derivation of a formula linking velocity and slope in an open channel by Chezy in 1775, introduced an important indirect method of flow measurement. In 1791, the concept of the hydrological cycle was extended by La Methiere, who explained that a part of the water from rain and snow flows off directly; a second part moistens the soil and evaporates or feeds the plants; and a third part penetrates to reservoirs at greater depths, from which it gradually issues as springs.

The systematic computation of discharges was first undertaken in the first half of the Nineteenth Century. Notable investigations were the Rhine (1809-1821 and 1820-1833), the Tiber (1825-1836) and the Garonne (1837-1846). In most cases the flows appear to have been computed by applying a formula to observed slopes and sections. During this period rainfall measurements were increasing in number and experiments were carried out on the effect of the location of rain gauges. In addition a number of experiments on evaporation were made. Even in countries where both rainfall and streamflow measurements were available for the same locality, there seems to have been no attempt to link rainfall and run-off quantitatively. The books, reports and articles of the period occasionally give the estimated flows of various rivers, but never suggest any method of estimating the flood flow. The estimation of mean stream flow as a constant fraction of rainfall was sometimes suggested, but the proportion used varied widely. In Ireland there were some rainfall records, but no measurements of evaporation or streamflow. Up until 1830, there was seldom more than one rain gauge operating at a time. In 1840 there were six; by 1850 this had increased to eleven, and in 1860 to nineteen. The *Reports* of the Bogs Commission (1809-1815) give the annual rainfall in Ireland as 30 in., evaporation from water as 36 in. and from moist earth covered with grass 25 in. The values for evaporation are probably taken directly from the results of Dalton's experiments at Manchester. In 1811, Nimmo in a *Report* to the Bogs Commission, stated that the water discharged in moderate rains was 1 cub. ft. per second for every 100 Irish acres, and that winter floods gave three or four times that quantity. Sir Robert Kane in 1845 estimated rainfall in Ireland as 36 in., and evaporation as 24 in., giving a run-off of 12 in., or one-third of the rainfall.

ARTERIAL DRAINAGE IN IRELAND, 1842-1852

In 1842, a small group of Irish engineers were faced with the task of estimating flood run-off from a large number of catchments, varying in size, slope, vegetation and other characteristics. Armed only with the rudimentary hydrological notions outlined in the previous section, they set out to solve this practical engineering problem, and succeeded in bringing to light many of the fundamental principles of storm-water run-off.

The problem arose because of the enactment in 1842 of the first Arterial Drainage Act. We are here concerned only with the work under this Act in so far as it affects the development of hydrology, and the greater part of the story must be omitted. Under the Act, the drainage works were to be designed and executed by responsible skilled officers of the central government under the control of the Board of Works. William Thomas Mulvany, then only 36 years of age, was appointed Commissioner for Drainage. The eldest son of Thomas James Mulvany, director of the Royal Hibernian Academy and biographer of the architect Gandon, he had spent one month as a medical student in Trinity College, Dublin, before deserting the medical profession and the university for the life of a surveyor and engineer. William Mulvany attracted the attention of Sir John Fox Burgoyne, a member of the Shannon Commission, and in the 1830's Mulvany was entrusted with drainage works on the River Shannon. Sir John Burgoyne, later a field marshal, was the most prominent military engineer of his time and was the first President of the Institution of Civil Engineers of Ireland. Sir John Burgoyne and William Mulvany drafted the Drainage and Navigation Act, which was passed in 1842 under Peel's administration.

On his appointment as Commissioner for Drainage and Fisheries, at a salary of £600 per year, Mulvany gathered round him a small group of engineers with varying backgrounds and experience. They included John MacMahon, a public works contractor and a veteran of the canal building era, who retained a high degree of physical and intellectual vigour despite his 70-odd years. In contrast was 21-year-old Samuel Roberts, first cousin of the future Field Marshal Lord Roberts of Kandahar, and possessor of a first-class mathematical education. At least two others had experience of the large-scale and varied works then being undertaken on the River Shannon. The group numbered six or seven in all.

From 1843 to 1845 the work on arterial drainage followed a normal course. By 1845, 50 memorials by landed proprietors seeking to initiate a scheme had been received. In 30 cases, reports had been issued giving the results of the survey and details of the design and cost of the proposed works. All legal preliminaries had been completed and work actually started in four districts. This in itself represents a substantial achievement on the part of a small group

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of men, but it was soon overshadowed by the work of the next few years.

In 1845 came the partial failure of the potato crop, followed by complete failure in 1846. In November, 1845, Mulvany drew up a comprehensive memorandum on the best means of expediting a programme of drainage works to relieve distress. As a consequence, an Act was passed in March, 1846, for carrying out Drainage Works under Summary Procedure. By June, works had been started in 20 districts, and 3,000 men were employed. The work continued to expand as follows:—

Date	Applications	Schemes started	Men employed
June, 1846 ..	120	20	3,000
September, 1846 ..	250	40	5,000
December, 1846 ..	370	60	5,000
March, 1847 ..	550	100	6,000
June, 1847 ..	640	100	17,000

Though only 120 schemes were actually started, over 400 reports were prepared and printed. The manner in which Mulvany and his team met this challenge is a bright chapter in the history of Irish engineering, but one which must be left for another occasion.

From 1847 on there was constant difficulty due to lack of money—works being suspended during the summer for lack of funds, and then money being made available in the winter when good use could not be made of it. In spite of all these difficulties, the final cost per acre of improved land was of the order of £5 15*s*., compared with an estimate of £4 5*s*., an increase of 35 per cent. The landowners who had clamoured for the work to be done, now baulked at the cost. The setting up of a House of Lords Committee in 1852, following the advent of a Tory Government, gave them their opportunity. Mulvany was retired on pension in 1853, and two years later left Ireland for the Ruhr, where he died in 1885. There he is remembered as one of the founders of the industrial prosperity of the region, and a street in Dusseldorf is named after him. Two of the mines he started (Hibernia and Shamrock) are still operating. A 200-page biography was published in Essen in 1922.

It is against this background—at first tranquil and later turbulent—that the advances in hydrology were made which are the subject of this paper. During the early period, a rudimentary form of the rational method was evolved and used for design purposes. During the abnormal years from 1846 to 1851, the experience of conditions in 120 districts of widely varying character indicated the limitations of this approach, particularly in the case of small upland catchments. A tabulation of measured flows was compiled, thus giving a most useful guide in the design of new schemes. Finally, in 1851, a number of papers were read to the Institution of Civil Engineers of Ireland by engineers from the staff of the Board of Works, in which the problem of flood run-off was discussed in such a fashion that long extracts from these papers could be included to advantage in modern text books on hydrology.

ESTIMATION OF FLOOD RUN-OFFS 1842–1847

Between 1843 and 1845 about 30 drainage reports were published by the Office of Public Works, each dealing with a separate river or catchment. An examination of these reports reveals a growing awareness on the part of the small group of engineers involved of the fundamental process of flood water run-off. They had no precedents to rely on, and the works they had to design were unlike any carried out in other countries. It is noteworthy that in a 32-page paper on arterial drainage read to the Institution of Civil Engineers in London by R. B. Grantham in 1859, there is no mention of the flow to be handled.

The O.P.W. practice, as revealed by the early drainage reports, was to design the improved channels to carry off a certain proportion of the maximum recorded 24-hour rainfall. Apparently, the viewpoint was that the percentage of rainfall used up by absorption and evaporation is constant throughout the year, so that if one-third (say) of the annual rainfall runs off as stream flow, then one-third of each day's rain runs off in the same way. This procedure was modified and refined as time went on, until it became a flexible design tool. The gradual modification in the procedure is best illustrated by taking specific reports as examples.

The report on the Templemore district (River Suir) by Edward Russell was published in November, 1843. Russell took the maximum rainfall as $1\frac{1}{2}$ inches in 24 hours, and assumed a run-off factor of 0·4. The basis of design was similar in the report on the Ardee district (River Dee) by Samuel Roberts published in December, 1843. In this case, Roberts took the rainfall as 1·6 inches per 24 hours, and the run-off factor as 0·4.

The next step forward is contained in a report by William Fraser on the Longford district (River Camlin) published in February, 1844. Fraser took the usual run-off factor as 0·4 for the southern part of the catchment, where the fall is about 5 ft. per mile, but increased the factor to 0·6 for the northern portion, where the fall is mainly 10 to 20 ft. per mile. All subsequent reports follow the same pattern, the run-off factor being varied to allow for the nature of the catchment. Common factors used were 0·4 for flat land and 0·6 for steep land (or else $\frac{1}{3}$ for flat land and $\frac{2}{3}$ for steep land), with an intermediate value of 0·5 sometimes used. In explaining the higher rate of run-off from steep catchments, the Board of Works engineers argued that there was less absorption on the steep ground, and also that the water ran off the higher ground before it could be evaporated, so that evaporation only takes place on the lower ground. Here we can discern a clear recognition of the tendency of steep catchments to peak sooner than flat catchments of the same size, but evaporation was still looked upon as the key factor in determining the peak rate of run-off.

In the earlier years, the rainfall taken was 1·5 in. or 1·6 in. falling in 24 hours. In a report on Drumcliff district in County Sligo, written in April, 1847, Robert Manning drew attention to a fall of 1·89 in. in 24 hours which occurred at Markree, Co. Sligo, in August, 1846. Manning suggested the use of 2 in. in 24 hours as the appropriate amount of rainfall for the design of western districts.

Thus, by 1847, this group of Irish engineers had improved the flexibility of their design method quite considerably. This method can be expressed as follows:—

$Q = 2{\cdot}52\,C\,i\,A$, where

Q = discharge in cub. ft. per min.

C = run-off factor ($\frac{1}{3}$ for flat ground, $\frac{2}{3}$ for steep ground)

i = max. rainfall rate ($1\frac{1}{2}$ in. to 2 in. per day)

A = area of catchment in acres.

Some of them considered that if the period of rise of the flood was substantially greater than 24 hours, the discharge should be decreased in the proportion of the two periods. No method of adjusting for shorter periods of rise than 24 hours had yet been devised.

The drainage engineers were very conscious of the economy obtained by using natural storage in the control of floods. A common practice was to lower the outfall from a lake and install a control weir to regulate the storage. In their reports they emphasised the economy in excavation obtained as a result of the smaller outflow from the lakes, and also the beneficial effect of the more uniform flow on mill power. They calculated the amount by which the inflow was reduced as a result of storage on the basis of a 24-hour period. Thus Robert Manning, in his design of the Drumcliff district, calculated the effect of 2 ft. 8 in. of storage in Glencar Lake as shown at the foot of column two; thus the provision of 2ft. 8in. of storage in Glencar Lake was estimated to reduce the peak flow from 500 to 186 cusecs.

Catchment area	8,960 acres
Run-off	$\frac{3}{4} \times 2$ in. per day = 1·33 in. per day = 500 cub. ft. per sec.
Original area of lake	283 acres
Area when lowered by 5 ft. ..	233 acres
32 in. per day on 233 acres ..	314 cub. ft. per sec.
Outflow	500 − 314 cub. ft. per sec. = 186 cub. ft. per sec.

Thus by 1847 a flexible method of calculating peak rates of flood run-off had been developed. The method was correct in its general approach, except that everything was calculated in terms of a period of 24 hours.

MEASURED FLOOD FLOWS

Mulvany and his colleagues took every opportunity to use measured flows as a check against their design methods. At first these opportunities were few, but during the famine years with drainage engineers resident in over 100 catchment areas, the chance of being on the spot and thus able to measure an unusually large flood increased enormously. The years, between 1847 and 1850 were relatively free from floods, but both 1851 and 1852 produced some remarkable flood flows.

The first notable estimate of the flood run-off from an Irish catchment was one by William Mulvany himself, and was based on lake levels on the River Shannon. Mulvany noted that Lough Derg rose 6 in. in 24 hours about once per year, and that in November, 1840, it rose 12 in. in less than 24 hours. Taking the catchment area as 2,300,000 acres and the area of Lough Derg as 30,313 acres, he calculated a rise of 12 in. in 24 hours as equivalent to a flow of 920,000 cub. ft. per min., or 0·40 cub. ft. per min. per acre. In the same way he calculated a rise of 6 in. in 24 hours in Lough Allen (near the head of the catchment) to be equivalent to a run-off of 1·4 cub. ft. per min. per acre from the catchment of 8,852 acres. It is interesting to note that Beardmore in his *Hydrology* quotes Mulvany's figures, but converts them incorrectly.

The same technique was used by John MacMahon in his study of the River Bann. He found that the greatest rate of rise in a record of the level of Lough Neagh kept from November, 1831, to July, 1832, was $4\frac{1}{2}$ in. in 24 hours. Taking the catchment area as 98,235 acres, he calculated this as equivalent to 0·93 cub. ft. per min. per acre. MacMahon estimated the outflow from the lake during this period as about 100,000 cub. ft. per minute, or 0·08 cub. ft. per min. per acre, thus giving a total inflow to the lake of about 1·01 cub. ft. per min. per acre. In his 110-page report on the Lough Neagh district, published in December, 1845, MacMahon contrasts this inflow, measured indirectly, with the run-off of 1·25 cub. ft. per min. per acre which would occur if the run-off were $\frac{1}{3}$ of $1\frac{1}{2}$ in. in 24 hours, and

"... should this quantity pass into the lake, in the same space of time that the rain gauges denote is allotted to its fall from the heavens"

he concludes that

"... the surplus waters, arising from the great fall adverted, require a greater length of time than 24 hours for their passage to the lough."

It is quite possible, however, that the short period of record was responsible for the measured flow being less than the value indicated by the rudimentary rational method used by the drainage engineers.

Records of lake levels were frequently used by the drainage engineer to determine inflow, but this was not the only method of measurement used. As far as can be judged, the most common of the alternative methods were gauging by weirs, float measurements or the use of a slope-velocity formula checked by occasional float measurements. Float measurements were usually made in mid-stream, and a coefficient used to reduce this mid-stream surface velocity to the mean velocity for the whole section. In making their returns of flow measurements, the district engineers noted any detail that might be relevant. Thus, besides rainfall and catchment area, the returns include such remarks as "works considerably advanced, one large lake acted as a reservoir"; "works far advanced, no lakes but catchment basin very flat"; "lakes not fully

Continuing Design

regulated, large part mountain catchment"; "none of the upper portion of the district opened."

The results of these measurements were collected and tabulated at the head office of the drainage section of the Board of Works. This tabulation is not extant, though a large number of the original results have been traced in surviving records—chiefly in papers to the Institution of Civil Engineers of Ireland, in engineers' reports of that period and in papers relating to the 1852 House of Lords Committee on Drainage in Ireland. Fig. 1 shows a logarithmic plotting of some of these measured flows. These represent a wide variety of catchments, the nature of the catchment (mountainous, average or well regulated) being indicated in the records. In each case the measured flow is expressed in cubic feet per minute per acre and is plotted against catchment area in acres. The lines drawn in the illustration are the writer's, but may be taken as representing the average experience of the drainage engineers of 100 years ago. Table I gives a list of some of the high flows recorded.

The occurrence of a flood of 8·7 cub. ft. per min. per acre from a catchment of over 25,000 acres is something to note, even at the present time. It is also worthy of mention that

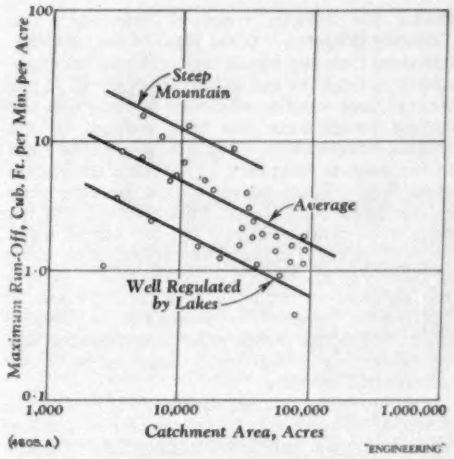

Fig. 1 Measured flood peaks—these flows revealed importance of time of concentration.

the flow of 13·02 cub. ft. per min. per acre from the 11,200-acre Annagh catchment in Galway was a summer flood.

Rainfall gauges were installed at all the principal drainage offices, and proved a useful supplement to the scanty network already in existence. Not only did these gauges supply additional ordinary records, but they gave an indication of the rainfall corresponding to the measured run-off. The following heavy falls in 24 hours are mentioned in various papers of the period relating to arterial drainage:

Location	Date	Inches per 24 hours
Cork	Nov. 17, 1846	3·60
Enniskillen	Oct. 12, 1845	3·02
Galway	Jan. 31, 1852	2·53
Roscommon	Feb. 22, 1852	2·03
Maam, Galway	Jan. 20, 1852	2·00
L. Dalla, Mayo	April 9, 1856	2·00
Castlebernard, Offaly	July 20, 1848	1·95
Sligo	July 17, 1846	1·89
Cavan	Jan. 1, 1851	1·83
Dublin, Yates	April 5, 1846	1·36
Castlebellingham	July 21, 1848	1·34
Cong, Mayo	Feb. 1, 1852	1·10

These figures clearly showed that the original figure of 1½ in. in 24 hours was insufficient, except on the east coast, and that in several cases a value of over 3 in. per day might be appropriate. The problem of heavy falls of a duration of less than 24 hours is discussed in a later section, but it is well to note here that in July, 1952, Thomas Mulvany measured a fall of 3½ in. in 6 hours at Ballyconnell, County Cavan.

To be continued

ENGINEERING HEAT TRANSFER*

A REVIEW OF RECENT DEVELOPMENTS

By Professor O. A. Saunders†

Heat-transfer problems abound in many industries, and their successful solution is frequently one of the main factors in efficient design of many kinds of industrial plant. In some cases it is the efficiency of heat transfer which determines the performance of the whole plant.

Usually the problem is to achieve a high rate of local heat transfer between a fluid and a surface and, especially when the fluid is a gas, to do so with a minimum of pressure loss. The methods normally used are ingenious forms of primary or secondary heat-transfer surfaces, control of flows to avoid wasteful pressure drop, and the use of materials and methods of fabrication designed to minimise unwanted temperature drops and to cheapen the cost as far as practicable. During recent years much research has been devoted to these problems and although the results are not spectacular they are of the utmost value in competitive industry.

New problems, or old problems with a new emphasis, calling for novel methods of solution, have also appeared on the industrial scene in recent years. The nuclear power reactor is one; among others are the cooling of gas-turbine blades, the overcoming of difficulties due to aerodynamic heating in high-speed flight. It may be of interest to review briefly the nature of some of these new problems and the methods employed to solve them.

NUCLEAR POWER REACTORS

Whatever the form of the reactor the transfer of heat from the fissionable material to the working medium of the power cycle is a major problem, calling for ingenious and novel methods. At present this development is still at an early stage and the future holds many opportunities for ingenuity.

In the first place, the permissible coolants and materials are few because of the necessity of avoiding wasteful capture of neutrons and the spread of radio-activity. Secondly, while the efficiency of the power cycle calls for a high coolant exit temperature, the maximum temperature of the fissionable material is limited by material or metallurgical considerations, this limitation being especially severe when metallic uranium in the form of rods is used. These restrictions are associated partly with the uranium itself, which undergoes various physical changes in the neighbourhood of 450 deg. C., and partly with the choice of canning materials which are chemically compatible with both the uranium and the coolant. The use of non-metallic uranium fuel elements, such as uranium carbide or uranium oxide, may provide a solution to some of these problems and thus permit the use of higher temperatures. Thirdly, since the rate of heat generation is determined by the neutron flux distribution and is usually non-uniform, the temperature distributions within the reactor of coolant and material are uneven; in the Calder Hall type of reactor, for example, the maximum uranium temperature occurs about three-fifths of the way along the coolant passages; a more even heat generation would therefore permit a higher exit coolant temperature for the same maximum uranium temperature. Fourthly, in gas-cooled reactors, the pressure drop must be kept to a minimum; in the Calder design the power for coolant circulation is about 4 per cent. of the heat removed and, since the power is a direct loss of useful output, it represents a drop of overall efficiency from about 25 per cent. (with zero coolant circulating power) to 21 per cent.

Gas-Cooled Reactor.—For low neutron capture the usable gases are hydrogen, helium, carbon dioxide, ammonia, and several hydrocarbons, with air as a doubtful medium. For high local heat transfer a high thermal conductivity is required; but the more appropriate criterion is the heat transfer per unit of circulating fan power, which, for gases, depends mainly on the square of the specific heat per unit volume of gas. Hydrogen and certain hydrocarbons are outstandingly good by this standard, with helium and carbon dioxide second best. The final choice of carbon dioxide for Calder Hall was based on availability, safety and general practicability. A great advantage also obviously accrues from the use of as high a pressure as possible in the coolant system, and the limitation here is the pressure vessel enclosing the reactor, once it has been decided to accept the inconveniences of a pressurised system which is found to be unavoidable for this type of uranium-graphite reactor. One of the directions in which both the power rating and the thermal efficiency of future gas-cooled reactors will be improved is by raising the operating pressure of the coolant, which becomes easier if the size of the reactor can be reduced.

The factors which decide the size and number of the coolant passages in a gas-cooled reactor are numerous and the optimising of the various dimensions is a complicated matter. For a graphite-moderated natural-uranium reactor, because of wasteful escape of neutrons, it is not practicable to have the uranium in thin plates or any form with a large surface area per unit mass, and bars of diameter of the order 1 in. are more or less unavoidable; it is thus found that, with a single-pass flow, the surface area for cooling is insufficient and fins have to be added to the light-alloy cans in which the uranium is enclosed, giving a five-fold increase in the surface area for the Calder Hall type of reactor. The disposition of these fins is most important. In the earlier stages fins parallel to the direction of flow were thought preferable from the point of view of minimising pressure loss, but it was found that the distribution of temperature over the flow cross-section became very uneven towards the exit of the passages, the fluid passing between the fins becoming much more rapidly heated than that passing in the outer channel. Such unevenness is very undesirable since it raises the can-surface temperature for the same average coolant temperature possibly by as much as 30 deg. C. Mixing devices designed to throw the heated coolant outwards were tried, but involved increased pressure loss. In the end, at Calder Hall, cross fins were used, and although it is not finally clear which type of fin is fundamentally superior for this application, the cross fins have proved very successful.

Much remains to be done to devise the most efficient arrangement of secondary surface which may take the form of complex fins designed to promote turbulence in the most effective manner possible. With the present maximum allowable

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uranium temperature at 400 deg. C. to 450 deg. C., the saving of even a few degrees of the temperature drop between the centre of the uranium bars and the coolant is of the greatest importance for high output and efficiency.

Liquid-Coolant Reactors.—If a liquid is used for reactor cooling the problem of pressure loss is no longer serious. Much attention has been given to liquid metals such as sodium and sodium-potassium alloy which are not only acceptable as neutron absorbers, but have a very high heat transfer coefficients over a wide temperature range. Heat flow rates of 3 million B.Th.U. per sq. ft. per hour are possible with a temperature difference between the liquid and the tube wall of only 200 deg. F., which is many times those encountered in modern steam plant, but the temperature drop across the thickness of the wall in a stainless-steel tube, 0·02 in. thick, is about 500 deg. F. and then becomes an important limiting factor. Liquid metals, however, suffer from the disadvantage of low specific heat, which may be particularly significant in small highly enriched reactors.

The use of liquid metals in industrial heat transfer is likely to grow in the future. The main problems are handling, compatability and pumping, but there is still some uncertainty about heat-transfer coefficients for liquid metals, the high thermal conductivity of which intro-introduces new problems, such as the effect of conduction within the fluid in the direction of flow; this is normally negligible with conventional gases and liquids.

Fast Reactors.—The design of fast reactor cores which, owing to the absence of moderating material, must be much smaller than those depending on thermal neutrons, will offer acute heat-transfer problems. Leaving aside reactor stability, the limit in reduction of size is largely set by the heat-removal problem. The possibilities of homogeneous reactor cores, such as by use of a fluidised bed of some kind are interesting. If the fissionable material can be dispersed into small elements, the problems of temperature drop within the material and of adequate surface area become easier, and the limitation is the spreading of heat within the coolant itself. Clearly these problems will call for great ingenuity from the heat-transfer engineer.

EFFUSION COOLING

By way of contrast to the nuclear reactor and other applications requiring high heat-transfer rates, there are many industrial problems in which the minimum heat transfer is required for the purpose of protecting a surface over which hot gases are flowing. Examples are the combustion-chamber walls of gas-turbines, the blades in a cooled-blade gas-turbine, and many problems in which hot gases pass through ducts. Although it may be possible to withstand the required temperature by using heat-resisting steels, these are expensive and considerable cost may be saved if wall temperatures can be reduced and cheaper materials used.

There are not many fundamental ways in which heat transfer between a fluid and a surface may be reduced, for a given fluid velocity. One obvious way is to insert a layer of a poorly conducting solid, such as a protective enamel or ceramic, but this involves mechanical problems of adhesion under considerable temperature stresses. A new suggestion which has attracted considerable attention in recent years is to use a fluid layer for thermal protection; this may be done by injecting into the hot gas stream a cold fluid, either through a series of discrete holes or slots, or through the pores of a suitable sintered metal or ceramic wall. The injected fluid forms a cool layer in contact with the wall and greatly reduces the heat transfer between the hot gas and the wall, and at the same time serves to remove heat from within the wall itself. The injected fluid may be either a gas or a liquid, the latter having the additional advantage of absorbtion of its latent heat at the surface.

The illustration, due to Bayley,* shows some results for various types of injection. The "cooling efficiency" is the ratio of the temperature drop from hot gas to surface, to the temperature drop from hot gas to injected coolant. Thus 100 per cent. cooling efficiency denotes that the surface temperature has been reduced to the coolant temperature. The abscissa is the ratio of the coolant mass flow to the main gas stream mass flow. These curves cannot be accurately extrapolated back to the zero abscissa, but the gain in cooling efficiency by the use of some form of effusion cooling as compared to using a plain surface is clearly substantial. Among the different methods of injection, the use of continuous injection is preferable to discrete holes. Sintered metals offer a convenient way of fabricating a wall of a duct or blade for continuous injection.

Obviously the relative advantage of using some form of effusion cooling is greatest in applications where the heat flux is high and this suggests gas-turbine applications, both for blades and combustion chambers. Nevertheless, the use of these methods has not yet been extensive in practice, but is promising. A louvred combustion chamber designed by the Shell Company has been successfully employed in an industrial gas-turbine.

* N.G.T.E. Report R.62 (1950.)

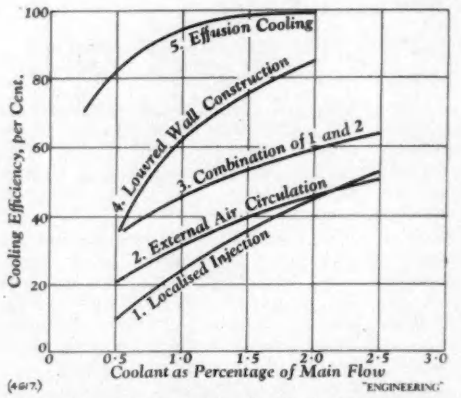
AERODYNAMIC HEATING

We now turn to an entirely different kind of heat-transfer problem. In most conventional applications the heat produced in the fluid by the action of viscosity has a negligible effect upon the heat transfer. But for high speeds of flow such as occur in aircraft applications this is no longer so. When air flows at high speed over an unheated surface, such as an aircraft wing, the heat produced in the boundary layer (where the shearing action is most intense) causes a rise in temperature above the main stream, the extent of which depends also on the rate at which the heat so produced is carried outwards through the boundary layer to the main stream. For gases the two processes of heat generation and heat transfer outwards are fundamentally linked, both for laminar and for turbulent boundary-layer flows, with the consequence that the equilibrium temperature reached by the unheated surface is dependent mainly on the Mach number of the flow, but to a less extent on the nature of the fluid and of the flow.

Aircraft or missiles flying at high speeds meet increasing difficulties of aerodynamic heating. The accompanying table shows temperatures attained under different conditions, neglecting the effects of radiation which would lower the temperatures somewhat; the upper figures in each row are for laminar flow, the lower for turbulent flow. If the duration of flight is short, the "cold" capacity of the skin may be sufficient to delay the heating-up process, and the use of specially designed skin structures may give remarkably long delay periods, up to several minutes, before equilibrium temperatures are approached. But for longer durations, when equilibrium is reached, a supply of "cold" is essential and two methods of solution are fundamentally possible. One is to install some form of refrigeration plant, which presents very serious problems in an aircraft or missile, the size of which tend to become smaller the higher the flight speed, so that interior space becomes more and more precious whether for carrying passengers or apparatus. The other method is to carry a "cold heat" capacity sufficient for the flight duration, and the most convenient source of cold is the aircraft fuel, the quantity carried bearing some relation to the flight duration. Indeed, by this means the effective calorific value of the fuel is slightly increased and the fuel saved by the heat abstracted from the atmosphere. The use of fuels which liquefy at very low temperatures, such as liquid methane or liquid hydrogen, would increase substantially the amount of "cold" carried. Major design problems occur in getting the "cold" to the right places in the aircraft.

TABLE.—*Temperatures in degrees Centigrade Attained by Aircraft Surfaces in Absence of Radiation Effects*

Altitude and air temperature, deg. C.	Flight Mach Number				
	1	2	3	4	5
Sea level, 15 deg. C.	64 66	206 216	428 456	725 774	1,086 1,160
25,000 ft. air at −35 deg. C.	6 7	124 132	313 336	565 607	878 937
36,000 to 100,000 ft. at −57 deg. C.	−20 −18	88 95	260 282	493 532	780 834



Comparison of methods of effusion cooling, in which a coolant is used to protect a surface from the effects of a passing hot gas. A cooling efficiency of 100 per cent. would obtain if the surface temperature were reduced to that of the coolant.

Problems of aerodynamic heating also occur inside ducts, blades, passages, etc., when the speed is high. An un-cooled turbine blade, for example, reaches a temperature which may be 100 deg. C. above the true gas temperature at the blade. In this case, however, the gas temperature in the blade passage is lower than at the entrance to the turbine casing because the increase of velocity in passing through the turbine nozzles is accompanied by a drop in pressure and in temperature, with the result that the temperature reached by the blade is not far from the gas temperature at the turbine inlet. The essential difference between the turbine and the aircraft is that, in the turbine, the observer is stationary relative to the blade, whereas in the aircraft the observer is moving with the aircraft surface.

A few highlights in engineering heat transfer have been mentioned. Another recent development is the control of radiation from luminous furnace flames, to which the work at the International Flame Research Committee at Ijmuiden, in Holland, has contributed notably. The improvement of heat transfer from a condensing vapour by promoting the condensate to form drops rather than a film has also been the subject of much work, the main difficulty being to find a promoter which will maintain its effectiveness over sufficiently long periods of time. Certain organic compounds have been found to be particularly effective.

Heat transfer problems are diverse and varied; future engineering projects will doubtless continue to throw up more new ones.

★ ★ ★

GENERATOR REGULATOR

Simms Motor Units Limited, Oak-lane, East Finchley, London, N.2, have produced an electronic regulator for low-voltage generators of automobile and commercial vehicle type. The unit incorporates transistors and has no vibrating contacts, nor will it cause radio or television interference. Control is maintained over both voltage and current. A grounded emitter circuit is used with silicon voltage and germanium current reference diodes. Blocking is effected by means of a germanium diode and an assurance light is connected in circuit to provide a non-linear resistance in operation.

Continuing **Design**

300 KW GAS-TURBINE

SIMPLICITY FOR THE USER

For power generation in medium-sized factories, for use in oilfields, or as a marine auxiliary power unit, a new 300 kW gas-turbine has been introduced by Ruston and Hornsby Limited, Lincoln. The first machine to be constructed, on order by a shipping firm as a marine auxiliary, can be seen at the Engineering, Marine, Welding and Nuclear Energy Exhibition at Olympia.

Known as the Mark TE, the new turbine is an open-cycle single-shaft machine with a centrifugal compressor and three-stage axial-flow turbine which develops 430 b.h.p. at 80 deg. F. for continuous rating. The turbine and compressor are mounted on a common shaft, as shown in the illustration (Fig. 2). The shaft extends forward from the compressor to provide a drive to the gearbox which is rigidly attached to the forward end of the engine, and from which the governor and accessory drives are taken. The combustion chamber is mounted at right angles to the engine axis just off the vertical position. The rotor speed of 19,250 r.p.m. is reduced to an output shaft speed of either 1,200 r.p.m. or 1,500 r.p.m., but reduction gears for other outputs to suit various driven components can be fitted. A comprehensive air cooling system is fed from the compressor and the set is thus rendered immune from damage from rapid starting and shut-down. Fuels for the Mark TE are British Standard Class "A" distillate oils and natural gas.

The Mark TE has been designed to exploit to the full the inherent simplicity, light weight and small bulk that the gas-turbine offers, while keeping component stresses low to ensure long operation on the minimum of maintenance. At the same time, by achieving a 3·5 to 1 compression ratio from the single-stage compressor and designing for a maximum cycle temperature of 800 deg. C., it is claimed that the overall thermal efficiency is higher than is usual for this type of turbine.

The single-shaft formula ensures close governing characteristics, even for large block load changes and while, for most applications, it will be usual to run the turbine at constant speed, it can, when required, be run at speeds below the designed output giving reduced powers down to self-driving speed (zero power output) at approximately one-third design speed.

CONTROLS

Control of the turbine is based upon a hydraulic servo system fed from the lubricating oil system, this arrangement providing automatic protection against a decrease in oil pressure. In the latter event the turbine is automatically shut down and the auxiliary motor-driven lubricating oil pump switched on. An unbalanced-ring over-speed governor is provided to shut down the turbine if the output shaft speed becomes excessive, and an excessive gas-temperature warning and shut-down control is fitted. An additional device to safeguard the set against excessive lubricating-oil temperature can be supplied if required. The hydraulic governor is capable of controlling the output speed within fine limits over a wide load range with adjustable droop characteristics.

Both the impeller and the separate inducer of the single-stage unshrouded compressor are manufactured from high tensile alloy steel or, alternatively, high strength Martensitic stainless steel where corrosion conditions are expected, as in marine applications.

The three-stage axial-flow turbine has unshrouded Nimonic 90 blades designed for equilibrium vortex flow, the blades being retained in fir-tree slots by Nimonic locking strips which prevent axial movement of the blading. One end of the strip is bent upwards after the blade has been inserted axially. The bending of the tabs is carried out as a mechanical operation by the use of a tool to ensure complete uniformity of the load applied and the angle through which the tab is bent.

The independent discs are forged in high-temperature stainless ferritic steel and the faces of these discs, together with the blade roots, are cooled by air taken from the compressor outlet and fed down the central shaft.

The rotating assembly is dynamically balanced as a complete unit after the rotors, the compressor baffle, and the turbine inlet volute are assembled on the centre shaft. During this process the baffle and the turbine inlet volute are supported clear of the shaft. The balanced rotating assembly is retained as a unit during subsequent assembly and removal, and accurate dynamic balance is thus maintained.

The stator blading is made from Nimonic 75 strip rolled to the blade profile. The blades, which are inserted through holes cut to the blade shape by an electro-etch process on both the outside stator and shrouded ring ends, are welded in position. All the blade twist required for equilibrium flow conditions is accommodated by the rotor blading.

The complete turbine stator is composed of eight independent segments, the ends of which are located on unsplit rings on the turbine central and exhaust housings. Gaps between the segments accommodate the circumferential expansion without any radial distortion, sealing strips being fitted between the segments to prevent gas leakage.

The rotor is mounted on two sleeve-type pressure-lubricated bearings, one forward of the compressor and the other at the rear of the turbine assembly. The bearings are steel-backed unsplit shells lined with copper lead and are pressed axially into the housings. The housing for the turbine bearing is air-cooled by air taken from the compressor delivery. The end thrust of the rotating assembly is taken on a white metal lined thrust bearing adjacent to the compressor bearing.

The exhaust spider, which supports the turbine bearing through the exhaust gas duct, is designed to keep the bearings central while the sheet-metal supporting struts expand and contract with variations in the exhaust temperature. This is achieved by anchoring them to the outer casing through flexible strips lying at right-angles to the struts themselves. The strips can flex readily but allow no side movement of the strut end. The struts carry the oil supply to, and the oil drain from, the turbine bearing and also air from the compressor to the annular cooling space surrounding the bearing housing.

The rotor speed of 19,250 r.p.m. is reduced to an output shaft speed of either 1,200 r.p.m.

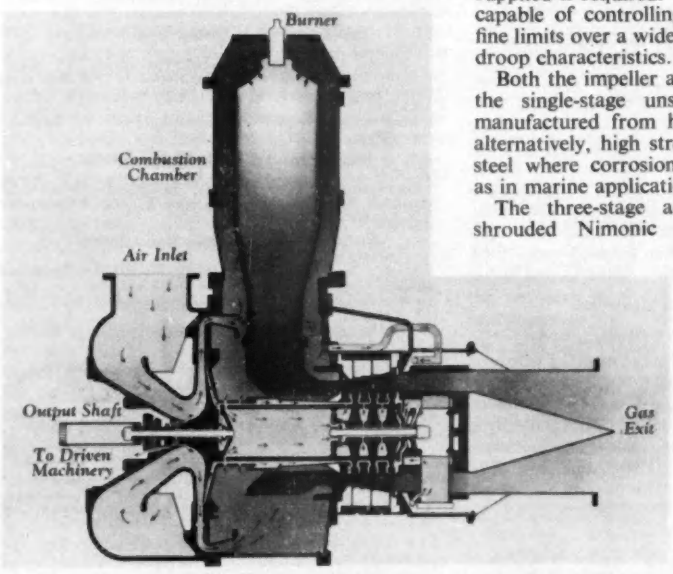


Fig. 1 (left) Flow diagram of the 300 kW open-cycle gas-turbine.

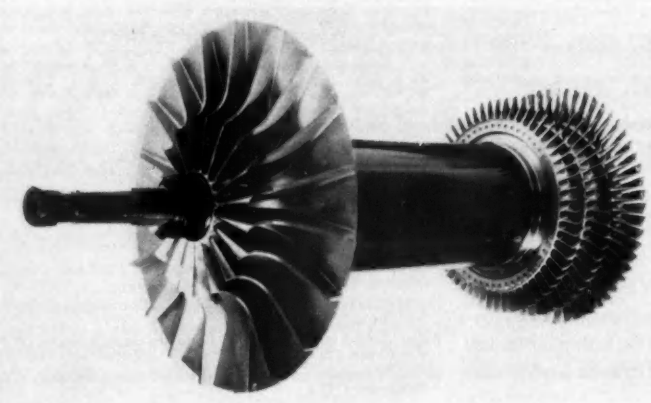


Fig. 2 (left) A centrifugal compressor and three-stage axial-flow turbine are mounted on a common shaft. The forward extension provides the drive to the gearbox.

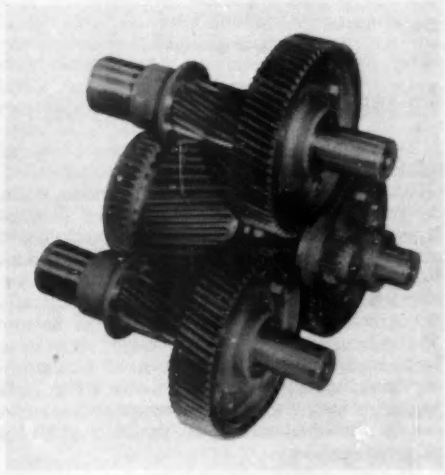


Fig. 3 (right) The three-layshaft double-reduction gear train.

or 1,500 r.p.m. through a three-lay shaft, double-reduction, single-helical train manufactured by David Brown Limited, shown in Fig. 3. All the main gears are case hardened and Maag ground to close tolerances, and, to ensure equal tooth loading between the three shafts, both the input pinion and the output wheel are located by the gear meshes only, neither having a central bearing. The quill shaft connecting the turbine and the high-speed pinion has gear-type flexible couplings at each end, and a flexible coupling is also inserted between the output wheel and the gearbox output shaft. All the bearings in the gearbox are steel-backed white metal lined shells.

AUXILIARIES

The auxiliary gear train is driven from the output shaft of the gearbox and provides four separate drive positions for the fuel pump, lubricating oil pump, governor and tachometer. The 24 volt electric starting motor is also mounted on the gearbox and drives on a gear ring on the output shaft. Starting is carried out by operation of a single hand wheel, which controls both the fuel supply and sequence of operation of the electrical circuits. The starting power is obtained from 24 volt batteries.

A flyweight-type hydraulic governor driven from the gearbox controls the fuel directly. A manual speeder control is positioned on the instrument panel.

Where appropriate, a combined fabricated frame is supplied for the engine and the driven unit. The rectangular portion of the frame under the turbine also serves as a lubricating oil tank, and an armoured sight glass in the side renders the oil level immediately visible. The gearbox provides one of the bearings for the driven unit and, because of the flexible coupling between the output shaft and the main gears within the gearbox, some small degree of misalignment between the driven unit and the turbine can be tolerated. Where the driven unit is already provided with two bearings, one additional gear-type flexible coupling at the driven end caters for all forms of misalignment. In this case, a shorter turbine frame can be used.

ACCESSIBILITY

The construction of the gas-turbine has been planned to give easy access to all components. The turbine blading can be inspected and the clearances checked without disturbing the bearing alignment, simply by removing the turbine split-outer casing which gives access to the stator segments. The exhaust ducting is left in place during this operation. The complete rotor assembly weighs only 208 lb. and can be easily removed by means of guide rails attached to the casings.

The use of a single combustion chamber avoids the matching problems associated with multiple chambers and burners, and greatly improves turbine accessibility, especially as, with the type of chamber used, no external air or gas ducting is fitted. All the engine-driven auxiliaries are mounted on top of the gearbox for ready accessibility.

* * *

DRAFTING MACHINE

A new drafting machine has been produced by the Angular Engineering Company, Limited, Glaskin-mews, Pembury-road, London, E.5, designed for use on drawing boards of all sizes. It consists of a vertical slideway carrying a drafting head, and it can be used in all positions from the horizontal to the vertical. No counter-balance weights are required. The vertical arm is controlled at both the top and the bottom of the board by a steel wire cable, running in ball-race mounted grooved rollers. The drafting head, consisting of two rulers set at right angles on a pivot that can be turned to any angle, can be moved up and down the slideway to the required position.

Metals and Materials

INSULATION AND PROTECTION OF HOT UNDERGROUND PIPES

The naturally occurring mineral-hydrocarbon gilsonites are employed for a variety of purposes. They are found in commercial deposits in Eastern Utah, U.S.A., and are high resin-content asphaltites believed to have been formed by the polymerisation of heavy petroleum. They occur in vertical veins varying in width from a few inches to 22 ft., and in depths ranging between 100 and 2,000 ft. Some varieties, when distilled, yield a light oil which, on further purification and treatment, gives a liquid suitable for use as a motor spirit. Other gilsonites, after selection, sizing and blending, possess the characteristics making them suitable for the insulation and corrosion-protection of hot underground pipelines employed for conveying steam or hot water for space heating, and similar applications. The crushed, screened and blended gilsonites used for this purpose have been given the name Gilsulate. After the pipes have been laid in a trench excavated in the soil, the Gilsulate, supplied in 2½ cub. ft. sacks, is spilled over the pipeline and hand tamped to settle it round the system. The remainder of the trench is then filled with earth in the normal manner.

When the pipeline is placed in service and becomes heated, the Gilsulate in contact with the hot piping and fittings fuses and bonds itself tightly to the surface forming an inner zone described as a flexible heavy-duty vapour barrier. This is water proof and a thermal and electrical insulator. Further thermal insulation, under wet or dry conditions, is provided by a second zone around the piping system which consists of sintered Gilsulate. An outer zone comprising unconsolidated Gilsulate granulated particles constitutes a flexible support for the piping system.

Three grades of the material are available, namely: type A for use in the temperature range 220 deg. to 300 deg. F., type B for the range 300 deg. to 385 deg. F., and type C for use at temperatures of between 385 deg. and 520 deg. F.

The material is marketed by the American Gilsonite Company, 134 West Broadway, Salt Lake City 1, Utah, U.S.A., and is distributed in this country by Morris Ashby Limited, 11 Bothwell-street, Glasgow, C.2.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"District Heating," by W. A. Gregory Carter. Central London Branch. White Hall Hotel, Bloomsbury-square, W.C.1. Mon., Sept. 9, 6.30 p.m.
"Some Applications of Electricity in a Large Modern Laundry," by R. Appleyard. South West London Branch. Prince of Wales Hotel, S.W.19. Thurs., Sept. 12, 8.30 p.m.
BIRMINGHAM
"Railway Electrification," by J. Bagdzinski. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham 2. Wed., Sept. 11, 7.30 p.m.
HALIFAX
"Fire Prevention by Nuclear Detection," by A. S. Radford. Halifax Branch. Crown Hotel, Horton-street, Halifax. Wed., Sept. 11, 7.45 p.m.
NOTTINGHAM
Branch Chairman's Address. Nottingham Branch. Mechanics' Institute, Trinity-square, Nottingham. Wed., Sept. 11, 7.15 p.m.
PORTSMOUTH
"Problems of Shop Lighting," by K. G. White. Portsmouth Branch. Wiltshire Lamp Hotel, Portsmouth. Tues., Sept. 10, 7.30 p.m.
READING
Discussion on "Hot Water and Heating from the Fridge." Oxford, Reading and Districts Branch. Agricultural Hall, 121 Oxford-road, Reading. Tues., Sept. 10, 7.15 p.m.
WEMBLEY
Chairman's Reception. North West London Branch. Century Hotel, Forty-avenue, Wembley Park. Mon., Sept. 9, 7.30 p.m.

Incorporated Plant Engineers

BRISTOL
"Fire Prevention in Industrial Buildings," by A. Walsh. Western Branch. Grand Hotel, Bristol. Wed., Sept. 11, 7.15 p.m.
CHESTER
"The Cost Accountant and the Plant Engineer," by R. G. Hall and B. J. Willson. Mersey and North Wales Branch. The Blossoms, City-road, Chester. Mon., Sept. 9, 7.15 p.m.
DUNDEE
Discussion on "Variable Speed Drives with Voltage Regulation Equipment." Dundee Branch. Mather's Hotel, Dundee. Mon., Sept. 9, 7.30 p.m.
GLASGOW
"Design and Application of Rotary and Reciprocating Air Compressors," by W. Scott. Glasgow Branch. Thurs., Sept. 12, 7.15 p.m.
MANCHESTER
Chairman's Reception. Manchester Branch. Engineers' Club, Albert-square, Manchester. Tues., Sept. 10, 7.15 p.m.
NEWCASTLE-UPON-TYNE
"Internal-Combustion Engines Applicable to Plant Engineering," by Norman Parry. North East Branch. Roadway House, Oxford-street, Newcastle-upon-Tyne. Thurs., Sept. 12, 7 p.m.

Institution of Engineering Designers

NEWCASTLE-UPON-TYNE
Chairman's Address and an Informal Discussion on Branch Affairs. North East Branch. Northern Architectural Association's Hall, 6 Higham-place, Newcastle-upon-Tyne. Mon., Sept. 9, 7.15 p.m.

Institution of Heating and Ventilating Engineers

BIRMINGHAM
"Acoustics: Sound Absorption and Insulation," by E. G. Ewing. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham, 2. Tues., Sept. 10, 6.30 p.m.
NEWCASTLE-UPON-TYNE
"Automatic Control with Particular Reference to Three Port Valves and Their Applications," by E. Hibbert. North East Coast Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Tues., Sept. 10, 6.30 p.m.

Institution of Highway Engineers

LONDON
"Pavement Construction on Christmas Island," by Major V. J. M. Smith and R. Airey. Institution of Civil Engineers, Great George-street, S.W.1. Fri., Sept. 20, 5.30 p.m.*
WARRINGTON
Open Meeting. North Western Branch. Town Hall, Warrington. Wed., Sept. 11, 6 p.m.

Institution of Locomotive Engineers

LONDON
Presidential Address by E. S. Cox. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, Westminster, S.W.1. Wed., Sept. 25, 5.30 p.m.*

Institution of Mechanical Engineers

NOTTINGHAM
"Nuclear Reactors," by Dr. M. D. Wood. East Midlands Branch. Joint Meeting with the Graduates' Section. Engineering Building, The University, Nottingham. Wed., Sept. 18, 7.15 p.m.

Institution of Production Engineers

BIRMINGHAM
Film Evening. Birmingham Section. College of Technology, Gosta Green, Birmingham 4. Wed., Sept. 18, 7 p.m.*
WOLVERHAMPTON
"Nimonic Presswork," by J. A. Grainger. Wolverhampton Graduate Section. College of Technology, Wulfruna-street, Wolverhampton. Wed., Sept. 18, 7.30 p.m.

Physical Society

LONDON
"Sound Propagation in Solids," by Dr. J. W. F. Bell. Acoustics Group. Physics Department, Imperial College, South Kensington, S.W.7. Thurs., Sept. 26, 5.30 p.m.

Royal Aeronautical Society

LONDON
45th Wilbur Wright Memorial Lecture on "Advanced Education and Academic Research in Aeronautics," by Dr. Clark B. Millikan (of the Guggenheim Aeronautical Laboratory, California Institute of Technology). Institution of Civil Engineers, Great George-street, S.W.1. Fri., Sept. 13, 6 p.m.*

Women's Engineering Society

MANCHESTER
"Training and Opportunities for Women in Engineering," by Miss Anne Shaw. Manchester Branch. Central Library, St. Peter's-square, Manchester. Mon., Sept. 30, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

*** An asterisk is placed where it is understood that tea is available prior to the time stated.**

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Physical Society, 1 Lowther-gardens, South Kensington, London, S.W.7. (KENsington 0048.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Women's Engineering Society, 25 Foubert's-place, London, W.1. (GERrard 5212.)

Production

WELDING IS FUNDAMENTAL TO ENGINEERING

Welding has been practised for centuries, but its development as a fast, adaptable and reliable production technique extends only over a relatively few years. There are many engineers practising to-day whose early acquaintance with the art—for such it was, not so very long ago—was confined to fire welding. This, though limited in scope for obvious reasons, was good enough if it was done properly, but it depended partly on the skill of the operator, and partly on such things as the quality of both the materials and the fuel, which were beyond his control, and there was little that could be done to check the soundness of the work. All too often a faulty weld was only discovered by failure in service. In the early days of gas and electric welding similar difficulties obtained, and it is hardly surprising that welding by these methods was looked upon, at first, as something to be used only if it was unavoidable.

How greatly this has changed in a comparatively short time, every engineer knows. To-day welding is accepted everywhere as a standard engineering production technique, taking its place alongside the older methods, and in some cases enabling work to be done which would otherwise be either impossible or uneconomic. The manufacture of very large boiler drums, for example, depends on welding, as the largest hollow forgings available would not meet the boiler designer's requirements. That welding is used in the production of pressure vessels over 60 ft. long, 6 ft. inside diameter and more than 5 in. thick, to work at a pressure approaching 3,000 lb. per sq. in., is not only an indication of how welding can solve a problem otherwise insoluble, but is also an eloquent commentary on the present-day status of welding. The very high quality and stress-characteristics possible with modern welding are also reflected in the many intricate and vital components which are produced by fabricating and welding for use in nuclear research and power production. It is difficult to see, in fact, how this work could even have been started had welding not reached the position it has. Similarly, it would appear unlikely that the motor-car industry could have developed to its present size without welding, which, in this case, makes mass production possible at an economic cost by the use of automatic and semi-automatic machines.

CONTROL OF THE PROCESS

Welding to-day shares only one thing in common with the older process; it is only successful if it is done properly. Research into the mechanism and metallurgy of welding has disclosed the basic facts, and welding has developed from an art into a science. To-day it is possible, on the basis of known facts, to design both a welded article or structure and the welds themselves, and to plan the welding procedure so that the results will be exactly as required.

Ample data now exist for both the design and execution of welded work. The British Welding Research Association have prepared a series of illustrated guides covering various processes, methods and designs, and there is an extensive general literature on the subject. The welding industry—for such it would now not be unreasonable to call it—has its own technical association the Institute of Welding, which is intimately concerned with the dissemination of technical information, and, in addition, numerous British Standards now exist covering many different aspects of welding. All the manufacturers of welding equipment issue detailed instructions on the use of their products, and some of them conduct training classes for operators and supervisors.

A further advantage possessed by the modern welding industry as compared with its predecessor is that it has at its disposal a wide range of non-destructive testing equipment. Thus, it is not only possible to design and carry out welded work of very high quality but also to submit it to tests which will show, without any possibility of error, whether or not it is up to the required standard. The welding of the fast breeder reactor at Dounreay, for example, which calls for precision work of a high order, was subjected to more than 3,500 radiographic checks.

WHAT ENGINEERS MUST KNOW

Since welding has developed from an art into a science, it is to be expected that the subject can only be covered fully by specialists, and the professional welding engineer is now a familiar figure in many large engineering works as well as in the establishments which are mainly concerned with welding to the trade. The assistance of such specialists is of great value, but it is not sufficient that engineers concerned with other branches of the profession shall merely be aware of the existence of their welding colleagues and know what they can do if called upon. It is far better to be acquainted with the general principles of welding and at least to know its possibilities and limitations. With such knowledge engineers can often visualise possibilities for welding within their own sphere of activity which may well be to their advantage.

A comprehensive display of welding machines, equipment and accessories such as that at the Engineering Exhibition, where one of the three halls is devoted to the subject, provides an excellent opportunity for seeing what the industry has to offer. Even a cursory examination will show that it has a great deal. Much that would have been considered difficult, or even impossible, only a few years ago, is now carried out as a matter of routine, and the industry has not been slow to adapt itself to the needs of users of the newer materials such as titanium and zirconium; these, together with plastics of many kinds can be welded by modern techniques and equipment. Welding and its closely-associated process, flame cutting, can now deal with a range of sizes, thicknesses and weights which have so far met industrial needs, and the equipment available ranges from simple hand welding guns and torches to fully-automatic machines which, according to the type of welding and the job, may travel along a component under their own power, be traversed on a boom, or be fed and discharged automatically with small work pieces from hoppers or conveyors. Such machines will have entirely automatic welding cycles, and will only need the services of an operator to set them up and start them. To accompany the welding equipment, hand or automatic, there are positioners and manipulators of all sizes, with capacities ranging from a few pounds to some hundreds of tons. These can carry, or sometimes incorporate, fixtures ensuring that parts to be welded shall be located accurately in relation to each other. Radiographic equipment is also available in the necessary variety.

THE FUTURE

It is always rash to forecast the future, but there is one trend which points the way, and which seems almost certain to continue. This is the development of more fully-automatic machinery. If it does, in fact, continue, then engineers will find themselves more closely involved with welding than ever, for some of the equipment, which will be of value to engineers, will also call upon their services to design the necessary mechanisms.

SOUND QUALITY IN QUANTITY

The Radio Show at Olympia serves as a shop window for advances in domestic electronics. Some companies show components and instruments that are unlikely to find their way into the average home, but most display radios, gramophones, and television sets. The advances over the year do not appear very startling. Television screens have grown a little larger, radio sets a little smaller. It would seem that the industry is at the position reached by the motor-car industry some years ago: the basic technical advances have been made, it is now a question of improving production methods.

It is nearly ten years since the discovery of the transistor and a significant proportion of the portable radios at this year's show use them. However, such sets are expensive. Printed circuits are being used to a greater extent too, though only a small proportion of the sets displayed are made in this fashion.

Perhaps it is in the field of high-fidelity sound reproduction that the chief advances in production techniques have occurred. Amplifying equipment of low distortion has been available for many years, but in the past there was no great demand for it. Consequently high quality equipment was expensive. However, with the coming of long playing records and frequency-modulated radio, public interest was aroused in the possibilities of better sound reproduction. Now several manufacturers produce high-fidelity equipment, and prices are falling.

The Mozart HF10 amplifier made by Pye Limited, Cambridge, is an example of the new range of sound equipment available. It has a frequency response extending from 3 c/s to 70 kc/s and produces an output of 10 watts. At an output of 9 watts its distortion is 0·3 per cent. A printed circuit is used.

Unlike audio amplifiers, loudspeakers with an ideal frequency response have not been practical. The present solution is to use several loudspeakers to cover the required frequency range. Often a moving coil unit is used for the lower register and one or more electrostatic units used for the upper register. The inherently wide radiating surface of the latter type of unit makes for realistic reproduction and it is possible that further development might lead to a single electrostatic unit for all frequencies.

To achieve a good bass performance with present units, the General Electric Company have developed the periphonic system. Two metal-cone loudspeakers are mounted in a V-shaped enclosure and power is applied so that the cones are driven in a push-pull mode. The differential action to the diaphrams produces cancellation of any residual harmonic distortion in the cones. The company claim that whereas a high grade paper-cone loudspeaker produces a total harmonic distortion content of 40 per cent. at 40 c/s, their system produces 2·7 per cent.

A trend in the television sets shown is the use of 21 in. tubes with 90 deg. cone angles. The shortening of the tube obtained by using larger cone angles leads to more compact sets; but the tubes require more complex circuits to drive them. American manufacturers are producing sets with 110 deg. cone angles and claim that the increased production costs are offset by the saving in storage and transport costs.

Miniature radios, small enough to go into a pocket, were displayed by three firms. The only one at present on the market is that made by Perdio Limited. It has five transistors and measures 5¾ in. by 3¼ in. by 1 in. Such sets have been slow in appearing because of the difficulty in producing transistors the characteristics of which lie within close tolerances. In addition to improvements in transistor production techniques, efforts are being made to evolve circuits that are less sensitive to variations in transistor parameters. Generally such circuits need more transistors and so require more space.

Atomic Review

The Prominence of Australia

THE development of Australian activities in the field of atomic energy has been extremely rapid during the past three years. The Australian Atomic Energy Commission was set up under the Atomic Energy Act of 1953. In their fourth annual report (for the year 1955 to 1956) the Commission reveal a wealth of achievements—not only in the prospecting and mining of uranium and thorium but in basic research and development of nuclear power.

So far much of the publicity given to the part played by Australia in the development of atomic energy by the western nations has emphasised the testing of weapons and the mining of uranium. Both are of great importance, particularly to Great Britain, but Australia's progress in research and reactor design has been most impressive since the programme started last year. Last summer, Professor J. P. Baxter, deputy chairman of the A.A.E.C., forecast that within 50 years Australia would be producing 60 per cent. of her power requirements from nuclear sources. Within that time these requirements will have risen twenty-fold to something approaching the present level of power production in the United States. To meet these needs Australia will require to produce 20,000 metric tonnes of uranium or 10,000 tonnes of thorium.

Professor Baxter's outlook on the future development of the country is one which many Australians share, with the conviction that the successful development of atomic power will make possible a considerable speeding up of the country's industrialisation rate. This is in sharp contrast to Canada's outlook and is a most instructive illustration of the different part energy needs and resources will play in the development of atomic power in various countries. Canada is a major source of uranium, and is proceeding with all necessary research in the production of uranium metal, for clearly uranium will be a major source of wealth for many years. Yet Canadian authorities consider that no substantial requirement for nuclear power is likely to arise before 1963 at the earliest, because of the considerable undeveloped water power in some areas and the availability of cheap fossil fuels in others. Canada is thus seeking to become a major supplier of atomic fuel—Australia is too, but foremost in the considerations of her Government and scientists must be the great and urgent needs of nuclear power to sustain industrial growth. This factor would grow vastly in importance should the world decide to ban the use and production of atomic weapons, for such a step would reduce considerably the incentive to develop atomic energy in North America, but not at all in Australasia or, for that matter, Japan, Africa and Europe, all of which urgently need nuclear power.

Research Programme

Australia's nuclear research programme is mapped out and largely organised and financed by the Australian A.E.C. As mentioned earlier, there are two main fields of activity. The first relates to the discovery and development of Australia's resources of uranium and other nuclear materials. The second relates to the development of the uses of atomic energy for industrial purposes, which includes work carried out in the universities and in industry as, well as in the research laboratories of the A.A.E.C.

The first official steps were taken by the Australian Government in 1947, when a group of twelve Australian scientists were seconded to work at the A.E.R.E., Harwell. In 1954 arrangements were made with the U.K.A.E.A. for an interchange of information in the general field of reactor technology and for additional Australian scientists to work in the Authority's laboratories pending the completion of laboratory facilities in Australia. Mr. C. N. Watson-Munro chief scientist, Australian A.E.C., commented that these arrangements, coupled with the considerable experience gained by some staff during the past decade, " have enabled Australia to begin her programme at an advanced level of technology and to avoid repetition of much of the early work in the development of atomic energy." Late in 1954 the Australian Government approved the installation of a research laboratory, at Lucas Heights, on the outskirts of Sydney, with an experimental reactor, the High-Flux Australian Reactor (HIFAR), which is similar to the British DIDO reactor. The initial capital cost of the scheme was to be £A5½ million, and the research establishment was planned to start at 400, including 50 senior scientists.

Experimental work at the Lucas Heights establishment began early this year and the construction of the reactor was expected to be completed during the summer.

Materials Testing Reactor

HIFAR is a research tool, to be used in the development of power production reactors to be built later in Australia. It is described as " a heavy-water moderated, high neutron flux, materials testing and research reactor." Australia's choice was influenced by the U.K.A.E.A.'s offer to make available the full details of this research reactor. Another most important factor has been the Australian A.E.C.'s conclusion that their first reactors should be of a type which is particularly suitable for metallurgical and engineering research. According to Mr. Watson-Munro the majority of the difficulties and problems remaining to be solved " lie in the field of the behaviour of materials under irradiation and at high temperatures and the economic processing of reactor products." With this in mind, the emphasis on buildings and facilities at Lucas Heights has been towards providing high neutron fluxes, methods of examining irradiated samples and loops, fabrication of special nuclear materials and, in fact, " a general bias " towards the metallurgical and engineering services.

The contract for HIFAR was placed with Head Wrightson Processes Limited (on the advice of the U.K.A.E.A.), who were the only British firm with previous experience of this type of heavy-water reactor and were engaged at the time on the construction of the reactor at Harwell. They also had orders for three reactors of similar design for the U.K.A.E.A. A contract for a maximum of £A937,000 was placed in June, 1955, for completion by June this year. Direct contracts were made with the A.E.A. for the supply of enriched fuel elements and with the U.S.A.E.C. for the supply of the heavy water needed as a neutron moderator in the reactor. The construction of the reactor at Lucas Heights is somewhat behind schedule, but is expected to be complete before the end of the year.

Novel Fuel-Moderator Systems

Australia's research into reactor systems will initially be concentrated on two types. One is a gas-cooled impregnated moderator-fuel element type, which can be shown to have good possibilities for electrical outputs from 10 MW to a base-load station of 200 MW. The other is a liquid-metal cooled type where the liquid metal is used as fuel carrier. In both cases the Australian A.E.C. propose to employ a thorium-uranium 233 conversion cycle. The Commission consider that a gas-cooled impregnated moderator type of reactor gives promise if a high-flux fuel

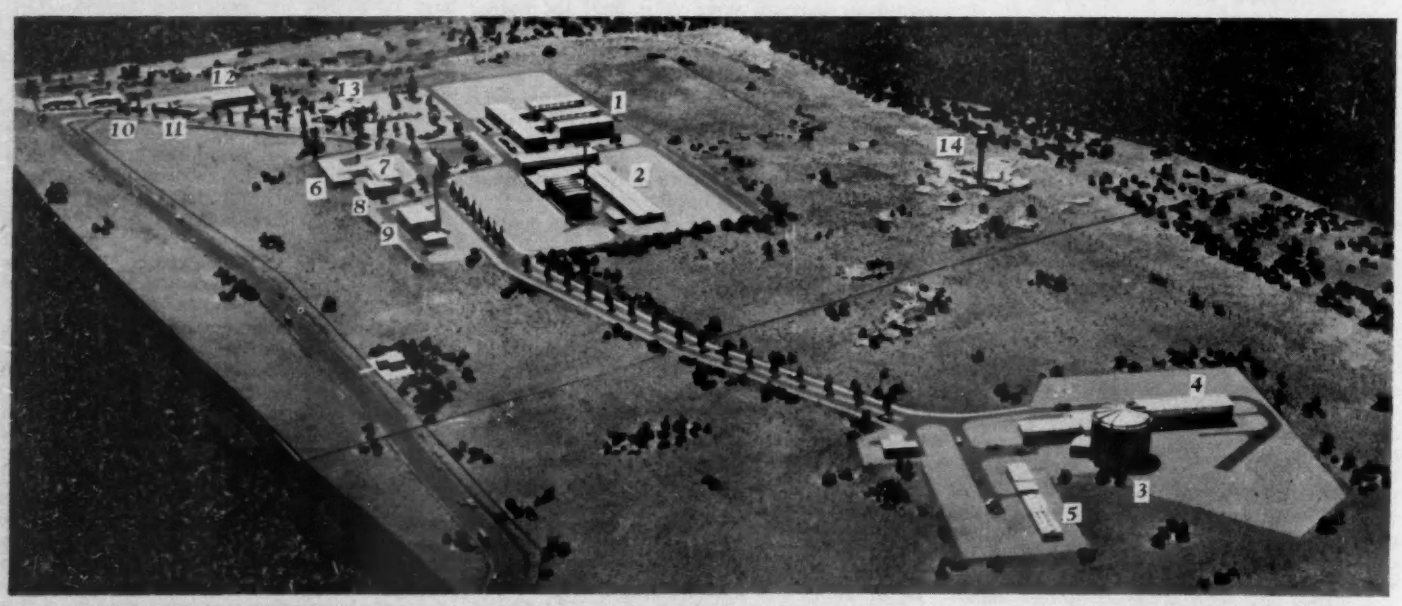


Fig. 1 Model of the Australian Atomic Energy Commission Research Establishment at Lucas Heights, near Sydney.

1. Metallurgy and Engineering Laboratories
2. Radio-chemistry and Chemical Engineering Laboratories
3. Reactor
4. Reactor Laboratories
5. Water Treatment Plant
6. Administration Building
7. Library
8. Lecture Theatre
9. Boiler House and Laundry
10. Gate House
11. Garage
12. Store
13. Canteen
14. Water Tower

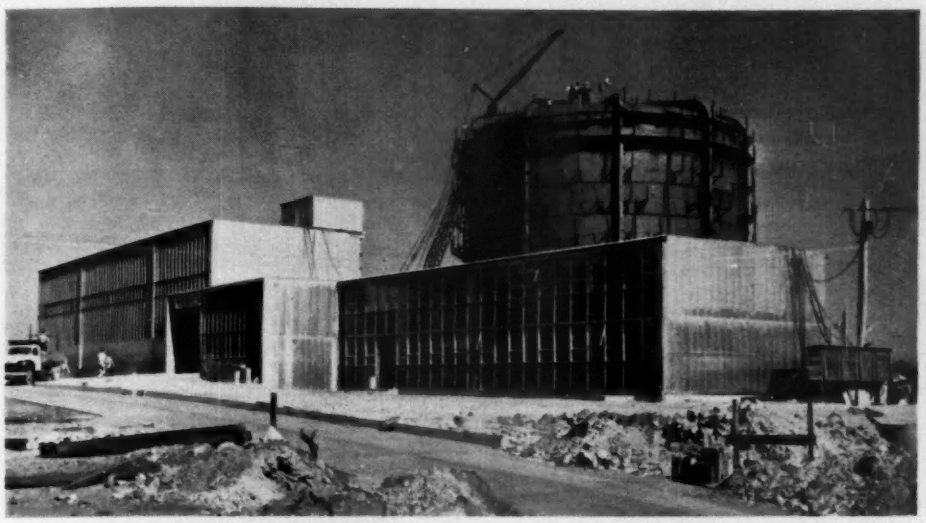


Fig. 2 Reactor laboratory and office block with HIFAR building at rear.

element can be developed. In the liquid metals field they are studying the considerable amount of work which has been undertaken by the Brookhaven National Laboratories using a solution of uranium in bismuth. They are also investigating the possibilities of sodium as a coolant fuel carrier and beryllium as a moderator. Work is proceeding in the laboratories in Sydney on the construction of a sodium loop and studies have begun on the construction of a sodium-uranium suspension with particles of diameters of less than 10 microns. An extensive series of compatibility experiments with beryllium and fission products is included in the initial stages of the A.A.E.C. research programme.

In considering the work which is being carried out or planned in Australia it should be borne in mind that the Commission have entered the field at a relatively late stage, albeit with a very good nucleus of experience and skills. As they have a good working relationship with their sister organisations in Britain and the United States, they have decided that it would be unwise to attempt to develop the kinds of power reactors which are already in an advanced stage of pilot-model construction. Also, Australia has a serious shortage of cooling water, especially in the many parts of the continent where atomic power stations are needed most, and A.A.E.C. have therefore a special interest in reactors that are " basically capable of development to gas-turbine temperatures of above 650 deg. C. . . . a field where thermodynamic efficiencies are higher and not a great deal of world effort has yet been applied." Finally, there is the wish to conduct the reactor experiment stage with Australian resources: " . . . this criterion, particularly when viewed in the light of current United Kingdom and United States experiments on fast breeder reactors, rules out a fast-reactor at least in the early stages of the Australian programme."

External Research and Training

As soon as the plans for Lucas Heights had matured, the A.A.E.C. gave all the Australian universities an outline of the kind of facilities which would be installed. The suggestion was that, although these facilities were primarily intended for use on the Commission's own research programme, they could be available to university research workers. Each university supplied details of their programme of research related to atomic energy together with some indication of how much space they would require at Lucas Heights and of the university staff involved.

During the year 1955 to 1956 research contracts were arranged involving a total contribution by the universities of £A38,700. Grants to the universities by the Commission had reached a total of £A68,700 last year. In their fourth annual report, they commented that research in the universities on particular subjects within the atomic energy programme " is contributing to the development of atomic energy " and " providing a greater spread of knowledge in this field, and creating groups of technologists capable of meeting Australia's needs." Details of the research contracts and the names of the directing professors are given in the A.A.E.C. report.

Prominent in the universities' research programme are investigations into the extraction of uranium from ores. The University of Melbourne is engaged on research into ore treatment, with particular reference to flotation methods. The University of Queensland is carrying out a major project on the treatment of uranium ores, and the New South Wales University of Technology is studying methods of extracting purified uranium nitrate from ores. This indicates the considerable importance attached by the Australian government and the A.A.E.C. to the mining of nuclear fuels. Current activities, discussed in subsequent paragraphs, indicate that this may well become one of the major industries of the Australian continent and a very substantial source of income.

The Commission are doing their best to ensure that the progress of their research programme is not hampered by a shortage of scientists and engineers. Apart, therefore, from the help given to the universities for carrying out their own research, the Commission have awarded undergraduate scholarships and post-graduate studentships—in geology, geophysics, metallurgy and chemical engineering.

Uranium Mining

Foremost in the A.A.E.C.'s programme is to " encourage and assist private enterprise in the search for uranium." In the annual report, the Commission review what appears to be most encouraging progress, particularly at the Rum Jungle undertaking. In their efforts to encourage mining companies and individual prospectors in making a positive contribution to the assessment of Australia's uranium potential and to establish " sufficient reserves for future national needs," the Government have placed a wide range of advisory and technical services at the disposal of private prospecting and mining enterprises. The practice of paying tax-free rewards for discoveries of economic significance and of granting tax concessions in respect of income from uranium mining—originally granted until 1960—has been extended for a further five years. In addition, the Commission have agreed to purchase parcels of uranium ore from a number of private producers.

In most of the uranium-seeking activities the principal Commonwealth agency is the Bureau of Mineral Resources, Geology and Geophysics, which operates in close consultation with the A.A.E.C. who provide the funds. In addition to providing aerial and ground surveys, the Bureau maintains a variety of consultant and laboratory services at Darwin, Melbourne and Canberra and also distributes maps and reports detailing the results of its surveys.

Airborne scintillograph survey work is carried out by four aircraft, two of them Douglas DC 3 and two Austers. Details of the work carried out last year are given in the Commission's report. Information is also given on the discoveries made and of the rewards paid out by the Commission. One individual, Mr. C. Walton, was paid £25,000 (the maximum reward) for his discovery of the Mary Kathleen deposits. This sum was paid out only once before, to Mr. J. White, who discovered the Rum Jungle deposit. Thus the two major deposits of uranium in Australia have been discovered by private individuals.

Electricity Production

The demand for electric power is doubling every eight or nine years. For this reason a bold atomic power programme can be expected to develop during the next few years. So far, little has taken place, except the suggestion that an atomic power station may be one of the two large power stations which may follow the Port Augusta scheme (the other being of conventional coal-burning design). Another announcement, late last year, was that a private enterprise atomic power plant was being considered by Mount Isa Mines Limited. This company pay £A8 per ton for their coal, which has to be hauled 760 miles, and is believed to be the most expensive in Australia.

The development of nuclear power in the Commonwealth will be watched with considerable interest by the British engineering industry. Few markets exist with a larger potential for British nuclear plant. The remark made recently by Professor Marcus Oliphant, Professor of Nuclear Physics at the National University, Melbourne, that " Britain is far ahead of the rest of the world in the commercial development of atomic power " suggests that the two countries will continue to work closely together. Another remark by Professor Oliphant was that " in the next generation we are certain to have sufferers from bone cancer and leukæmia as a result of radiation " and that, although it will mean only an increase of one per cent. in the annual death rate and therefore not important statistically, it is " very important if you happen to be one of the poor devils who get these complaints." Professor Oliphant and his colleagues are more outspoken about the dangers of radiation than most scientists and are taking measures which should make Australia safer than most countries with a nuclear programme.

General Notes

Radio-Isotopes: International Conference

Radio-isotopes will be the subject of an international conference to be held in Paris from September 9 to 20 this year. Convened by UNESCO, the Conference will be strictly scientific in character and its main purpose will be the exposition and discussion of new ideas and methods for the use of radio-isotopes in biology, physiology, agriculture, medicine, oceanography and industrial research.

The inaugural session will be held on Monday, September 9, in the Grand Amphitheatre of the Sorbonne, with subsequent sessions in the Ecole de Médecine. Sir John Cockcroft, director of the Atomic Energy Research Establishment at Harwell, will preside over the Conference.

Work Begins at Hunterston

Preliminary work has begun on the site at Hunterston, Ayrshire, for the atomic power station which the General Electric Company is to build for the South of Scotland Electricity Board. The preliminary work now in hand includes the building of a temporary access road 1½ miles long, the provision of essential services, including water and electricity supplies to the site, and the erection of accommodation for the various contractors.

The Human Element

Towards a Free Labour Market

From the beginning of this month skilled coal and steel workers in the Iron and Steel Community countries have been able to seek work in any of the member States. A special labour card is issued by the regional employment services for 29 trades in coal and 27 in steel. A worker in possession of this card can find work without having to produce a labour permit as a foreign worker.

The significance of the move is as a trial balloon in the problem of harmonising wages and working conditions in the member countries of O.E.E.C. In a free market there should be a tendency towards harmonisation. Since there is full employment at present throughout the western European coal and steel industries, it is not likely however that the opportunity to move to alternative areas of employment will exert much influence at first. Nevertheless, there may be some effect in due course when the European Common Market and possibly the Free Trade Area scheme as well are on the verge of taking steps in wage harmonisation, a subject which at present is considered one of the most difficult to tackle under the Treaty of Rome which set up the common market.

Kid Gloves on the Clyde

The strike of foremen and rate fixers at the Clyde yards of Harland and Wolff Limited last week was a mild affair as such matters go. At first it was thought the strike had been called because a wage demand had not been met and because someone had been wrongfully dismissed. It turned out that the real cause was the disagreement between management and labour as to whether the Association of Supervisory Staffs, Executives and Technicians could negotiate for the men.

The strike has been a short and amicable affair but it has pointed once more at the need for a thorough overhaul of labour-management relations in the shipbuilding industry. In this day and age a major industry should not be held up by last-minute arguments as to who is to negotiate with whom. The shipbuilding industry is in a key position in labour relations. It inevitably exercises great influence over the engineering industry and its knowledge and pre-occupation about the state of the order book make it something of a bell-wether on the labour side about the relation of wage demands to future trade prospects. Ill-feeling in the shipbuilding industry is particularly dangerous on the Clyde at present where tempers were more ruffled than elsewhere during the shipbuilding strike earlier this year. There is plenty of dry tinder lying about in that quarter if someone carelessly starts a fire nearby.

Facts for U.S. Workers

A new compendium for American workers has recently been issued by the U.S. Department of Labour called *The American Workers' Fact Book*. It gives 433 pages of fairly readable information on a whole host of subjects in which organised labour might be interested. This is the Department's contribution towards giving the American working man a factual background on economic conditions, a job which is considered to fall within the Department's terms of reference.

Presumably this will have to be an annual exercise, otherwise it will become quickly out of date. The question arises whether such a publication would be of value in this country. There is no doubt that in America the booklet fills a gap and it is exceedingly comprehensive in coverage. It has clear merit as a work of reference. The United States is not well endowed with journals on current economic affairs which will appeal to the worker. There are several weekly magazines in this country having no counterpart in the United States which, in any event, has the circulation problems of a subcontinent. In addition, the United States journals on current affairs suffer from the point of view of labour, of reflecting the American apotheosis of business—a tendency which is accentuated by the American preference for getting its magazine economic fare in terms of personality and warmed-up drama.

The idea is perhaps less in need of expression in a factual compendium in this country—but the idea of an official handbook for labour is at least worth an airing.

Ten Pounds a Week

Average weekly earnings of manual workers in industry reached a new record of £10 4*s.* 7*d.* last April. This is £5 0*s.* 1*d.* or 98 per cent. more than it was 10 years ago, when the Ministry of Labour's half-yearly inquiry into wage levels was first begun. The interest of these figures is that they include all bonus payments, overtime, etc., and therefore give a more realistic picture of workers' incomes than the amounts paid out in wages. Since April, 1947, wages have risen by 68½ per cent. and the difference between this and the rise in earnings is the measure of both the country's prosperity and the continuing shortage of labour.

The gap between wages and earnings has for long been the target of trade union activity. Any slackening in the tempo of industry would be reflected immediately in a big fall in average earnings. The pressure, therefore, more particularly at this year's Trades Union Congress, will be for a reduction of the gap. Union leaders want a shorter official working week and a substantial cut in overtime working. Last April, average weekly hours were about one-eighth higher than the basic working week: 45·0 hours in April. In manufacturing industry the average was 48·1 hours, at a time when the recovery in demand for motor vehicles and household appliances had not had their full impact on employment. With more overtime now being worked in these industries, the average must be nearing 50 hours.

An apt comment on the current situation is provided by a university lecturer, Mr. H. A. Turner, who has made a survey of wages in this and other connections. In his report, *Wage Policy Abroad*, published as a Fabian pamphlet, he concludes: " . . . if the energy so far devoted to the struggle for (and against) bigger money wages could be released to improve productivity increases in money wages similar to those actually achieved might be combined with stable living costs."

Rail Clerks Jump the Gun

Even as the delegates to the 89th Trades Union Congress were proceeding to Blackpool, the annual round of wage claims began. The Transport Salaried Staffs Association sent a formal request for a review of the wages of their 90,000 members, which was received by the British Transport Commission last week. T.S.S.A.'s letter was based on the fact that there has been a 2 per cent. rise in the cost of living index in the 5 months since they were granted a 5 per cent. wage increase (last March) and, of course, on the unfavourable comparison between the increase they got and those granted later to engineering, shipyard and steel workers. The union further justify their action by reference to the B.T.C.'s proposals for " periodical reviews of wages " which were included in the terms of the March settlement.

The annual round of wage claims has thus begun without waiting for the public rejection of voluntary restraint and the condemnation of the Government's wages and price council expected at the Congress. But the support for Mr. Cousins' resolution embodying these items could hardly be other than deafening and unanimous. It is on T.S.S.A.'s action, not on the more thoughtful attitude of trade union leaders at meetings with the Government, that likely developments should be assessed.

There will be everything in this year's race: the cost of living chase, differentials between grades and between unions, sharing in productivity increases, etc. The mood of the unions is unmistakably militant, and irrepressible.

Overtime Ban

Mental nurses have declared war on overtime, and 23,000 of them who are members of the Confederation of Health Service Employees working in hospitals started a progressive ban on September 1. They planned that, at first, only three mental hospitals should be affected, involving about 600 nurses, but the ban will eventually spread to all hospitals in England and Wales. The second and third phases, scheduled to start at intervals of two weeks, will each apply to a further 600 nurses. The situation appears to be very delicate, and there is substantial support for the mental nurses' aims among other hospital staffs. There is a strong feeling that the treatment of mental nurses reflects official thinking on the subject of mental health and that it is high time it were changed. The nurses (about 35,000, half of them men, are employed in British mental hospitals) are asking for a council to regulate their salaries and working conditions. They want a reduction of their working week from 48 to 44 hours and a " reassessment of the value of the mental nurses' service " by payment of an extra £100 a year on all salaries.

There is little doubt that the nurses mean to fight for their demands, and that in so doing they will be handicapped by " unpopularity," particularly with their patients and with the public. But they have waited long and patiently, and their case would seem to be stronger than most.

Music Hath Charms

That cheerful and often distorted din over factory loudspeakers in the afternoon which goes by the name of " Music While You Work " has been one of the more remarkable features of industrial human relations. Some workers seem to like it. Many would resent its removal as a background noise which they have become accustomed to and which they consider is theirs as a right—as part of the terms of engagement.

A number of studies in Canada have recently been made claiming that music in the factory or office can have a beneficial effect on output. It goes without saying that the phenomenon has been clothed with a very ancient lineage. It goes back as far as the building of the pyramids. Others might think that it might go back even further, for whistling and humming at work may be older than articulate speech. Be that as it may, studies carried out by the Stevens Institute of Technology have shown that efficiency of filing clerks and verifier operators (presumably in punched-card operations) has been increased by music during office hours. Bank employees have been found to like it as well and so have telephone solicitors in a classified advertisement department.

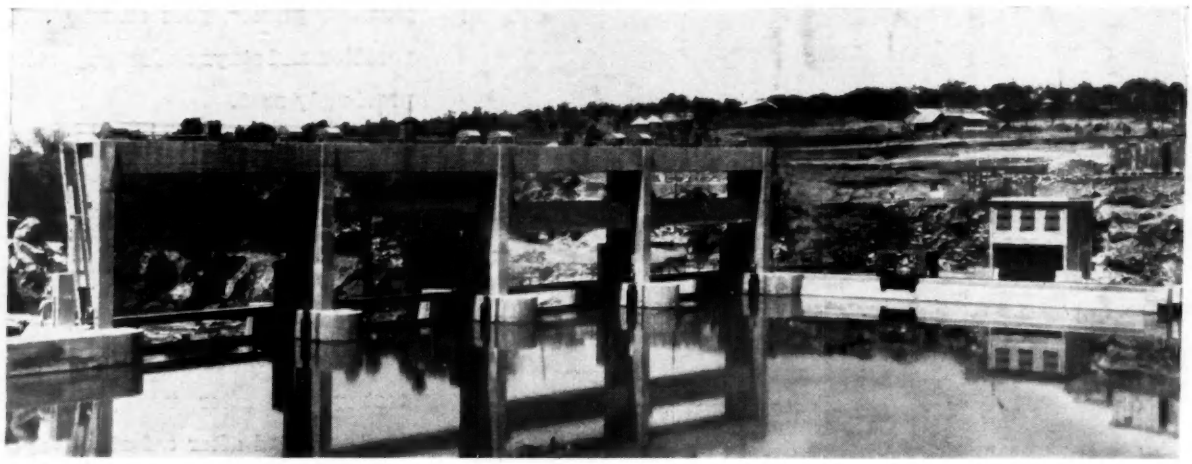
One aspect of the subject deserves further serious investigation. There is increasing concern in industry about noise and its effects on efficiency. Presumably music, under scientific definition, can be classed as a noise. The relation of music to noise in the office and factory might be significant in the study of the wider problem.

ENGINEERING

An Illustrated Weekly Journal

If it's equipment for

HYDRO-ELECTRIC PROJECTS



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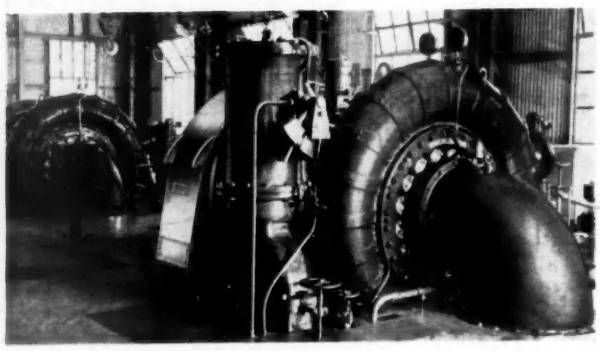

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